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# ON THE DISTRIBUTION OF CATCHES BY TUNA LONG-LINE

Tomokichi YOSHIHARA

(Received May 16, 1954)

## 1. Introduction

The long-line fishery for tuna is one of the most important fisheries of Japan. Some years ago, I attempted to examine the distribution of catch of it. At first, it was supposed that fishes are distributed evenly in the sea, therefore the distribution of fish caught by each hook of the long-line gear would show the uniform distribution along the line. In order to affirm this assumption, data on the catches by the tuna long-line were examined. Next the existence of the optimum water temperature, at which the maximum catch may be expected, was investigated. The optimum temperature will be obtained by determining the swimming layers and the temperature of them. Hence it was necessary to investigate the position of hook under the surface of the ocean and the observation of water temperature at each layer.

In the paper written in Japanese (1951-4), I proposed a method, on the deterministic argument, which gives the depth of the hook. At the same time, in order to determine the vertical distribution of water temperature data were collected. In this paper the following problems will be treated: (i) The horizontal distribution of the catches by the long-line gear, (ii) The vertical distribution of the catches by the long-line gear and (iii) The vertical distribution of water temperature deduced from the observational data. Further, in order to gain a clear, a brief explanation on the method of fishing and the construction of the long-line gear were added.

## 2. The method of fishing and the construction of the long-line gear

In the papers by Shapiro (1950), June (1950), Shimada (1951a), Ego and Otsu (1952) and Murphy and Shomura (1953) detailed explanations for this fishery are given, from which the general ideas of the long-line fishery for tunas can be deduced, so only a brief description will be given in the following.

The long-line gear is a drifting long-line designed to fish at subsurface lavels for tunas and other large pelagic fish and is essentially a method by which numerous hooks are lowered to the depth at which it is desired to fish. A vessel of large size will generally sets out many miles of lines. The main line is suspended at 200 to 300 meters intervals, with 15 to 40 meters float lines, attached to glass floats. Between floats, 5 to 6 dropper lines of 10 to 30 meters in length are hung from the main line at equal intervals. Thus the exploitation of the subsurface water has been possible. The long-line gear has been operated at all seasons in a number of areas. In one day's fishing a catcher vessel of the 100 to 200 ton class set 300 to 400 baskets in one continuous connected line with

1500 to 2000 hooks. The fishing grounds by month and by species are illustrated in the report published by the Nankai Regional Fisheries Research Laboratory (1952).

Parts of the long-line gear that is suspended horizontally below the surface of the water is known as the main line. The main line is made of cotton or hemp. It is supported to its horizontal position by lines attached to float or bouys. Bamboopoles are used generally one to a basket, to serve as a maker indicating the whereabouts of the long-line in water. Three types of bouys are in use;—glass, metal or wood. The lines used in the actual fishing are supported from the main line at the preassigned intervals. Each branch line consists of four pieces (Fig. 1), viz. 1) A length of cotton line, 2) A "Sekiyama", 3) A wire leader i.e. "Kanayama", 4) A tin plated iron hook.

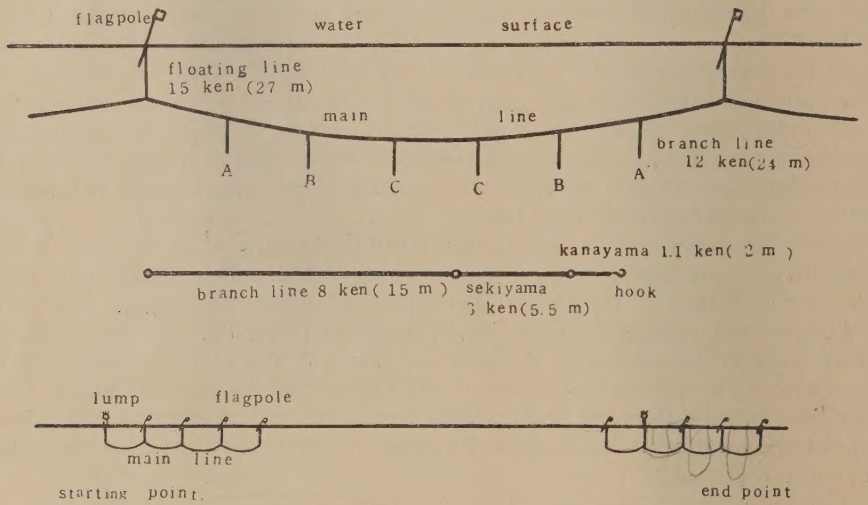


Fig. 1. Construction of long-line gear.

Long line vessels of the most widely used standard classes are from 100 to 300 tons. The large vessels are usually made of steel. Recently a few vessels are of more than 300 tons and can fish up to 300 to 400 baskets of gears. The basic unit of long-line gear is the "basket". The term "basket" is derived from the special type container, woven of bamboo, in which the gear is stowed. It is similar in significance to the term "skate" used in the Pacific halibut fishery. A basket consists of a length of main line to which a number of branch lines, usually five or six, are attached at intervals.

Although each type of gear tends to catch primarily the species for which it has been designed, the catch composition during fishing operations is usually varied and various tunas as well as sharks may be taken on a long-line. As to the names of fish caught by the long-line, see Table 1. Long-lines are sometimes designed to fish at both shallow and deep levels. In recent years such construction

has been favoured by fishermen, since the addition of several deeperfishing branch lines to a shallow-type gear permits the catching, in certain areas, of a wider variety of species. But in this paper these constructions are omitted.

Table 1. Names of important fish caught by the long-line gear. Throughout the report the vernacular names of fishes are used. These, with their usually accepted scientific names, are given in this table.

| | | |
|---|---|---|
| I. Thunnuidae | 1. Thunnus | Maguro or Meji (young fish)...Black tuna... Thunnus orientalis |
| | 2. Germo | Binnaga or Tombo...(Long fin or) Albacore... Thunnus germo |
| | 3. Parathunnus | Mebachi...Big-eyed tuna...Parathunnus sibi |
| | 4. Neothunnus | Kihada or Kiwada .....Yellow-fin tuna..... Neothunnus macropterus |
| II. Isotiophoridae | 5. Isotiophorus | Basyo kajiki...Sail-fish...Istiophorus orientalis |
| | 6. Makaira | Kajiki...(Stripped) Marline....Makaira mitsukurii |
| | | Kurokawa Kajiki....Black swordfish (or Marline)...M. mazara |
| | | Shirokawa Kajiki...White marline...M. marlina |
| III. Xiphiidae | 7. Xiphias | Mekajiki....(Broadbill) Swordfish.....Xiphias gladius |
| IV. Katsuwonidae | 8. Katsuwonus | Katsuwo...Skipjack...Katsuwonus vagaus |
| V. Others | 9. Squali | Yoshikiri (or Aota)...Shark...Prionace glauce |

Fishing at deep levels with the long-line gear is accomplished by setting the main line slack so it will sag. This sag should take the form of a catenary. A wide range of theoretical or potential hook depths can be achieved by simply altering the distance between bouys when the gear is set. The actual depth attained by the hooks is, of course, also dependent on such factors as currents, which may cause the line to stream out.

When the gear is constructed many factors are considered and the dimensions of the different parts of the gear are determined as follows:

The main line is suspended by float lines at depth of at least 15 meters below the surface level, because if the main line were placed on or near the surface of the ocean, passing vessels could cut or tangle it in their propellers.

In the exploratory and commercial long-line fishing operations, data were gathered, which showed that the behavior of each species in a particular area was distinctive and that the greatest commerical concentrations of each were found at almost specific depths. Accordingly designs of the gears were determined so as to catch the types of tunas which were caught. On the other hand, it should be noted that the same species of tuna inhabits at different levels of water in different regions.

On the methods of locating long-line fishing ground, it is pointed out that the success of the Japanese long-line fishery has been largely depended on the ability to locate fishing grounds that are capable of yielding abundant quantities

of fish. Exploratory vessels compiled and dissemiated to the industry a huge amount of data on the catch obtained during their fishing voyages, see e.g. Shimada (1951) and Reports of the Nankai Regional Fisheries Research Laboratory. Moreover, these catch records were correlated with various oceanographical factors, such as water temperature, current drift and depth of the ocean bed. Commercial vessels were thus given not only the general location of new fishing grounds but also the hydrographical conditions under which the best catches were likely to be made.

In this paper attempts were made to deduce the relationship among water temperature, depth of swimming layers and abundance of catch, but the relation between the catch and current drift was not given because there were no data to clear up it. The migrating tunas tend to follow the course of a current, and the long-line can be set where a strong current exists and the tunas are known to be plentiful. However, areas where the tunas are available are more easily located by looking for barriers to movement. Barriers to movement may be an island, a reef, a submerged bank or difference in water temperature between water masses. From these barriers the last one has been selected. Murph and Shomura showed another factor which determines the abundance for tuna.

In the experiments used in this study, the gears were put down on the early morning and taked-up on the afternoon. Light bouys in place of glasspoles and glass bouys, may put out at intervals along the line. These bouys not only serve to indicate the whereabouts of the long-line to fisherman, if the gear should be taken in when it is dark, but also warn away other vessels that may put their long-line out in the same area. The usual speed of the vessel is about three to six knots during the operation, but the actual speed depends on many factors—the experience of the crew, the water current, the direction of the wind, the running capacity of the line hauler, the number of the fish caught etc.

## 3. Material

The statistical data used in this study are from two sources. They are called A and B respectively.

| | | A | | B | |
|---|---|---|---|---|---|
| 1. | Period of fishing | From June 17 to July 29, 1949 | | From Oct. 7 to Nov. 10, 1950 | |
| 2. | Fishing ground | the South Pacific Ocean | | N. 37°–39°, E. 174°–180° | |
| 3. | Name of vessel | Daini Tsurumaru | | Daigo Kuroshimaru | |
| 4. | Tonnage | 180 tons | | 151 tons, 250 HP, 30 meters | |
| 5. | Number of crew | 25 | | 24 | |
| 6. | Number of basket | 330 | | 300 | |
| 7. | Surface water temperature | 28°C or more | | 20°–22°C | |
| 8. | Number of hooks of one basket | 5 | | 5 (Ramie line), 6 (Cotton line) | |
| 9. | Names and number of fish caught | Kurokawa<br>Tombo<br>other fish | 187<br>180<br>35 | Tombo<br>Mebachi<br>Aota<br>Kajiki<br>other fish | 276<br>224<br>171<br>129<br>45 |
| 10. | Name of collector of data | Akira Kawamura | | Tokuichiro Kamei | |

| | | | |
|---|---|---|---|
| 11. | Length of one main line | About 190 meters | 270 meters (Ramie line), 320 meters (Cotton line) |
| 12. | Daily beginning and end of fishing (hours) | From 3-8 to 12-24 | From 3-8 to 12-23. |
| 13. | Interval of submersion of line during one fishing operation | 9-14 hrs. | 9-15 hrs. |

## 4. Acknowledgements

I am greatly indebted to Messrs. A. Kawamura and T. Kamei for kindly providing the more elaborate data used in this study. These contributions are gratefully acknowledged.

## 5. On the relation between the slackness of the main line and the depth of each point on it

1) Representation of the coordinates of the point on the main line by means of the parameter $\varphi$.

Suppose that the form of the main line at the settled position in the sub-surface water is the form of catenary as shown in Fig. 2, where points $A_o$ and $A_n$ are two end points on a main line and $A_i(i=1, 2, \ldots, n-1)$ is $(n-1)$ points which divide

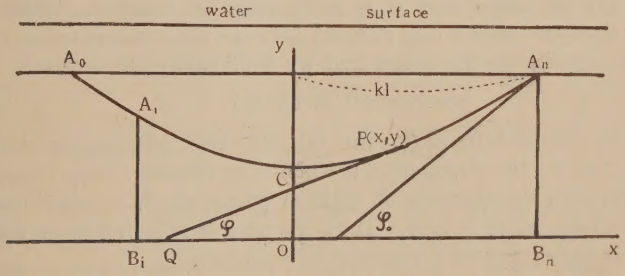


Fig. 2. Form of the main line

the main line $A_o$ $A_n$ into $n$ equal parts. Usually $A_o$ and $A_n$ lie on the equal level. Let the deepest point on the line be $C$ and the equation of the curve be

$$y=\frac{a}{2}(e^{x/a}+e^{-x/a})=a\cdot\cosh\frac{x}{a} \qquad (1)$$

Draw a tangent $PQ$ of the curve at the point $P(x,y)$ on it, then this tangent will cut the abscissa at the point $Q$ and the slope of $PQ$ is given by $\tan\varphi$, where $\varphi$ is the angle between the tangent $PQ$ and abscissa. It is easily to show that

$$\tan\varphi=\sinh(x/a) \qquad (2)$$

Hence equation (1) takes form as a function of $\varphi$

$$y=a\cdot\sec\varphi. \qquad (3)$$

Let the value of $\varphi$, when $P$ coincide with $A_o$ or $A_n$, is $\varphi_0$ and the origin of co-

ordinate axes O. Take $n-1$ points $B_i(i=1, 2, \ldots, n-1)$ on the $x$ axis so as to $A_iB_i$ is parallel to $y$ axis. Let the length of the arc $CP$ be $s$ and

$$2l=L=\text{arc } A_0A_n=\text{(known length of the main line)},$$

$$k=\frac{\overline{A_0\,A_n}}{\overset{\frown}{A_0\,A_n}}$$

then from (1)

$$A_nB_n=y(kl)=a\cdot\cosh(kl/a)\,. \tag{4}$$

There exists a relation

$$s^2=y^2-a^2 \tag{5}$$

hence

$$\text{arc } CA_n=l=a\cdot\sinh(kl/a) \tag{6}$$

and

$$l^2+a^2=a^2\cdot\cosh^2(kl/a)\,. \tag{7}$$

As $y\,(kl)=a\cdot\sec\varphi_0$, we get from (4)

$$\sec\varphi_0=\cosh(kl/a) \tag{8}$$

thus by means of (7)

$$a=l\cdot\cot\varphi_0 \tag{9}$$

From (9) we know that $a$ is a function of $l$ and $\varphi_0$, where $l$ is known length. We shall not utilize this relation because the determination of $\varphi_0$ by the experiment is tedious on the ocean and we shall apply the relation

$$\sec\varphi_0=\cosh(k\cdot\tan\varphi_0) \tag{10}$$

which may be obtained from (8) and (9). By this relation we may represent the parameter $\varphi_0$ as the function of $k$ which may obtained from the experiments.

By definition, the distance of division points $A_0, A_1, \ldots, A_n$ along the curve is constant and its value is $2l/n$. Thus we may get the following formula which represents the value of $y$ as a function of $l$ and $\varphi_0$,

$$y_{n-j}=l\cdot[(1-2j/n)^2+\cot^2\varphi_0]^{1/2} \tag{11}$$

where $j\leqq[n/2]$ i.e. $j$ is smaller than the greatest integer not larger than $n/2$.

On the other hand we get from (1), $y_{n-j}=a\cdot\cosh(x_{n-j}/a)$

hence

$$\begin{aligned} x_{n-j}&=a\cdot\cosh^{-1}(y_{n-i}/a)\\ &=l\cot\varphi_0\cdot\cosh^{-1}[1+\tan^2\varphi_0(1-2j/n)^2]^{1/2}\\ &=l\cdot\cot\varphi_0\cdot\sinh^{-1}[\tan\varphi_0/(1-2j/n)] \end{aligned} \tag{12}$$

2) Determination of $k$.

We have shown that when the value of $\varphi_0$ is given or determined experimentally, the value of $x$ and $y$ may be calculated. But as stated above the determination of $\varphi_0$ is not easy because it is difficult to draw the tangent at the end point $A_n$ on the ocean. Thus we have to utilize the relation which gives the value of $\varphi_0$ as a function of $k$, since the value of $k$ may be determined by several ways. The simplest formula is

$$k=\frac{\text{Horizontal distance between two end points } A_0A_n}{\text{Length of the arc } A_0A_n} \tag{13}$$

Hence if we can decide the distance between two end points $A_0A_n$, we can calculate the value of $\varphi_0$.

As the fishing vessel runs along the main line the distance $A_0A_n$ can be determined if we may observe the mean velocity of the vessel or if we may observe the distance directly by the optical or electrical methods. In the example given below the value of $k$ will be determined by the above formula.

After we have got the value of $k$ we must deduce from it the value of $\varphi_0$ by equation (10). In order to facilitate this calculation a table and a diagram were made. For this purpose the equation (10) have been transformed into the form

$$\tan\varphi_0=\sinh\cdot(k\cdot\tan\varphi_0) \tag{14}$$

from which

$$k=\frac{\sinh^{-1}(\tan\varphi_0)}{\tan\varphi_0}$$

$$=\frac{2.3025851}{\tan\varphi_0}\cdot\log_{10}(\tan\varphi_0+\sec\varphi_0)\,. \tag{15}$$

The corresponding values of $k$ and $\varphi_0$ are given in Table 2 but in order to get the results rapidly the relation between $k$ and $\varphi_0$ is represented in a diagram (Fig. 3).

Table 2. Values of $k$ as a function of $\varphi_0$ (Degree).

| $\varphi_0$ | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | 0.99995 | | | | 0.99987 | | | | |
| 10 | 0.99488 | | | | | 0.9884 | | | | |
| 20 | 0.9791 | 0.9769 | 0.9746 | 0.9722 | 0.9696 | 0.9669 | 0.9641 | 0.9611 | 0.9583 | 0.9548 |
| 30 | 0.9514 | 0.9479 | 0.9442 | 0.9404 | 0.9364 | 0.9323 | 0.9281 | 0.9236 | 0.9190 | 0.9142 |
| 40 | 0.9092 | 0.9040 | 0.8987 | 0.8931 | 0.8873 | 0.8814 | 0.8752 | 0.8688 | 0.8621 | 0.8552 |
| 50 | 0.8481 | 0.8407 | 0.8330 | 0.8250 | 0.8168 | 0.8082 | 0.7993 | 0.7901 | 0.7806 | 0.7706 |
| 60 | 0.7603 | 0.7497 | 0.7385 | 0.7270 | 0.7150 | 0.7025 | 0.6895 | 0.6759 | 0.6618 | 0.6470 |
| 70 | 0.6316 | 0.6156 | 0.5987 | 0.5811 | 0.5627 | 0.5433 | 0.5229 | 0.5015 | 0.4788 | 0.4549 |
| 80 | 0.4296 | 0.4026 | 0.3739 | 0.3431 | 0.3099 | 0.2740 | 0.2346 | 0.1909 | 0.1414 | 0.0826 |

In Fig. 3, upper curve represents the relation of equation (15). The increment of $k$ when $\varphi_0$ increase a small quantity may be derived from (15),

$$\Delta k=\frac{\Delta\varphi_0}{\sin\varphi_0}\left(1-\frac{k}{\cos\varphi_0}\right)$$

$$=\frac{\Delta\varphi_0}{\sin\varphi_0}\left[1-\frac{2.3025851}{\sin\varphi_0}\log_{10}\tan\left(45^\circ+\frac{1}{2}\varphi_0\right)\right]\,.$$

Let $\varphi_0=60^\circ$ then $k=0.7603$ and $\Delta k=\Delta\varphi_0\times1.1547\times(1-1.520)=-0.601\Delta\varphi_0$. Assume $\Delta k_0=0.01$ radian$=34'23''$ then $\Delta\varphi_0=-57'.2$. On the left side these values are

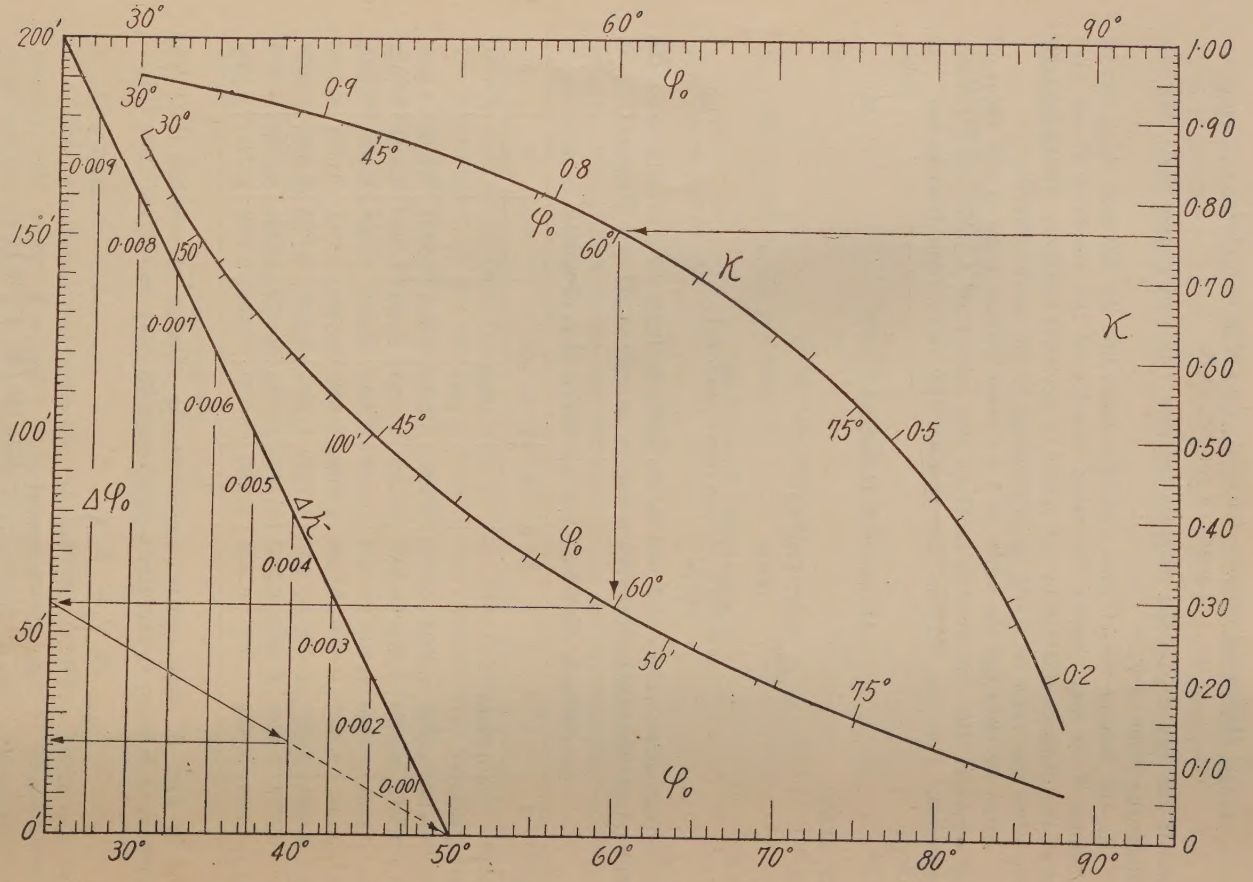


Fig. 3. Diagram to facilitate the calculation of the value of $\varphi_0$.

scaled. Further the triangular part may be used to utilize the three places of decimals of the value of $k$.

In the diagram the value of $\varphi_0=59°37'$ is obtained when the value of $k=0.764$. In this example $\Delta k=0.764-0.760=0.004$ and the value of $\varphi_0=60°$ corresponds to $k=0.7603\div0.760$ from Table 2. From the auxiliary part on the left corner of the diagram we get $\Delta\varphi_0=-23'$, thus $\varphi_0=60°-23'=59°37'$. Notice that $\Delta k$ accordingly $\Delta\varphi_0$ is negative. For the details of explanation see Yoshihara (1954).

After the value of $\varphi_0$ is obtained we have to calculate the value $(1-2j/n)^2$ for each $j$ and $n$. These values are given in the paper written in Japanese. (Yoshihara, 1951)

3) Direct determination of depth of hook

We may obtain the values of $\varphi_0$ rapidly by means of Fig. 3, but in order to get the depth of each hook we have to calculate the values of the coordinate by equation (11) and (12) and although this is not difficult, it is not simple. In the tuna long-line fishery, it is usual to use five or six hooks. Therefore the depth of each hook in these case was determined for all range of the value of $k$.

Let the coordinate of arbitrary point $P_j$ on the curve $A_0A_n$ be $(x_j,y_j)$, then by the relation (5) the length of arc $CP_j$ is

$$s^2=y^2(x_j)-a^2=a^2\cdot\cosh^2(x_j/a)-a^2$$
$$=l^2\cdot\cot^2\varphi_0(\cosh^2(x_j/a)-1).$$

If the point $P_j$ divides the are $CA_n$ into the ratio $m$: $n-m$, we may obtain from this relation

$$\left(\frac{m}{n}l\right)^2=l^2\cdot\cot^2\varphi_0\cdot\sinh^2\frac{x_j}{a}$$

hence

$$x_j=l\cdot\cot\varphi_0\log_e\left[\frac{m}{n}\cdot\tan\varphi_0+\left\{1+\left(\frac{m}{n}\cdot\tan\varphi_0\right)^2\right\}^{1/2}\right]. \qquad (12')$$

On the other hand

$$y_j=l\cdot\left[\left(\frac{m}{n}\right)^2+\cot^2\varphi_0\right]^{1/2}. \qquad (11')$$

Suppose that five hooks were used then the points $P_1$ and $P_2$ divide the arc $CA_0$ into three equal parts, each of which is $l/3$. Let the vertical distance from the point $P$ and $P_j(j=1, 2, \ldots)$ to the horizontal line $A_0A_n$ be $d$ and $d_j$, particularly the distance from $C$ to the line $A_0A_n$ be $d_0$, then

$$d_j=y(kl)-y_j=a\cdot\cosh\frac{kl}{a}-a\cdot\cosh\frac{x_j}{a}$$
$$=l\left\{\left(1+\cot^2\varphi_0\right)^{1/2}-\left(\left(\frac{m}{n}\right)^2+\cot^2\varphi_0\right)^{1/2}\right\}$$

whence

$$d_j=l\left[\frac{1}{\sin\varphi_0}-\left(\left(\frac{m}{n}\right)^2+\cot^2\varphi_0\right)^{1/2}\right] \qquad (16)$$

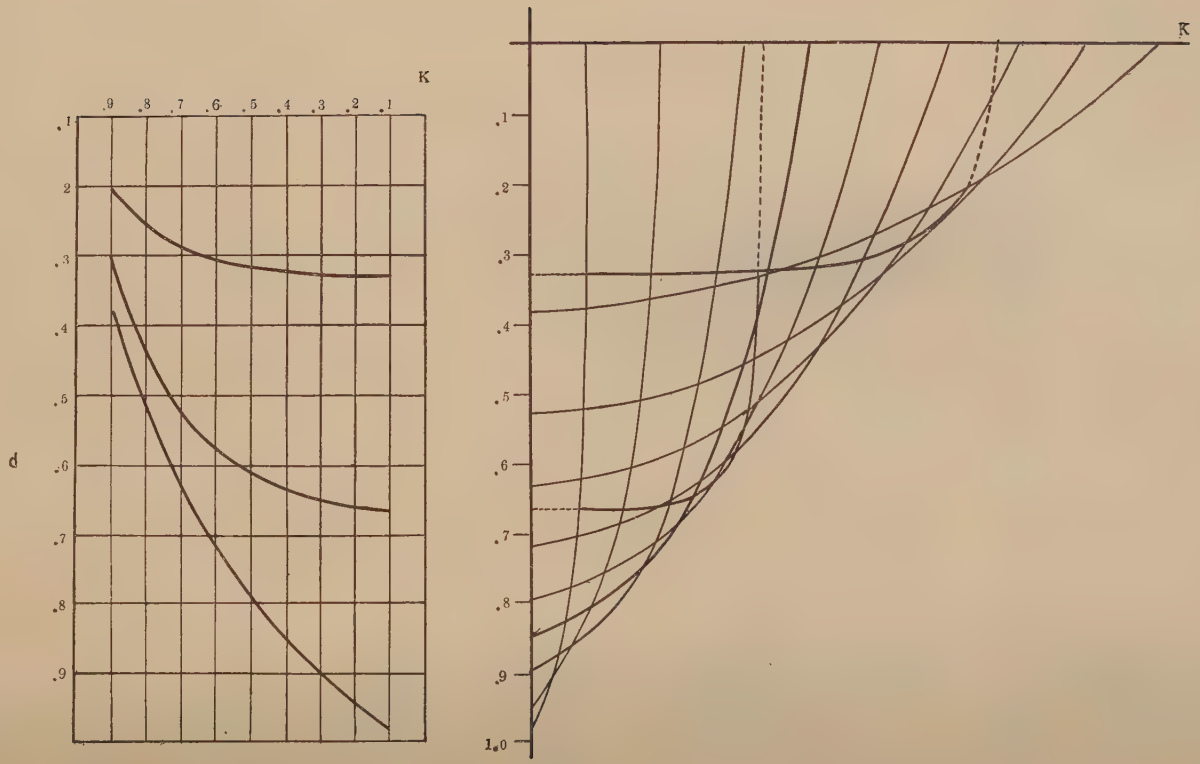


Fig. 4 (I). Diagram showing the shapes of main rope for each value of k and the relation between k and d when five hooks were used. Left pannel shows the increase of d when k decreases, right pannel shows the locus of shallow, middle and deep hooks when k changes.

and

$$d_0 = y(kl) - a = l \cdot \tan \varphi_0/2 \ . \qquad (17)$$

The value of $d_1$ and $d_2$ may be obtained by putting in (16) $m:n=1:3$ and $m:n=2/3$ respectively.

Similarly when six hooks are used $d_1$, $d_2$ and $d_3$ may be obtained by putting $m:n=1:7$, 3:7 and 5:7 respectively. The values of these vertical distance are given in Table 3 and there are shown the positions of hook in Fig. 4 when five or six hooks are used.

Table 3. Values of $d_1$ and $d_2$ when five hooks were used

| k | $\varphi_0$ | $\tan \varphi_0$ | $\operatorname{cosec} \varphi_0$ | $\cot^2 \varphi_0$ | $1/\sin \varphi_0 - (1/9+\cot^2 \varphi_0)^{1/2}$ | $1/\sin \varphi_0 - (4/9+\cot^2 \varphi_0)^{1/2}$ |
|---|---|---|---|---|---|---|
| 0.89862 | 42 | 0.90040 | 1.49448 | 1.23346 | 0.33492 | 0.19912 |
| 0.79933 | 56 | 1.48256 | 1.20622 | 0.45496 | 0.45387 | 0.25786 |
| 0.70247 | 65 | 2.14451 | 1.10338 | 0.21744 | 0.53018 | 0.28982 |
| 0.59874 | 72 | 3.07768 | 1.05146 | 0.10557 | 0.58597 | 0.30984 |
| 0.50147 | 77 | 4.33148 | 1.02630 | 0.05330 | 0.62083 | 0.32078 |
| 0.40263 | 81 | 6.31375 | 1.01247 | 0.02509 | 0.64342 | 0.32725 |
| 0.30992 | 84 | 9.51436 | 1.00551 | 0.01105 | 0.65600 | 0.33059 |
| 0.19090 | 87 | 19.08114 | 1.00137 | 0.00275 | 0.66394 | 0.33264 |
| 0.08261 | 89 | 57.28916 | 1.00015 | 0.00030 | 0.66636 | 0.33326 |
| 0.00000 | 90 | $\infty$ | 1.00000 | 0.00000 | $^2/_3$ | $^1/_3$ |

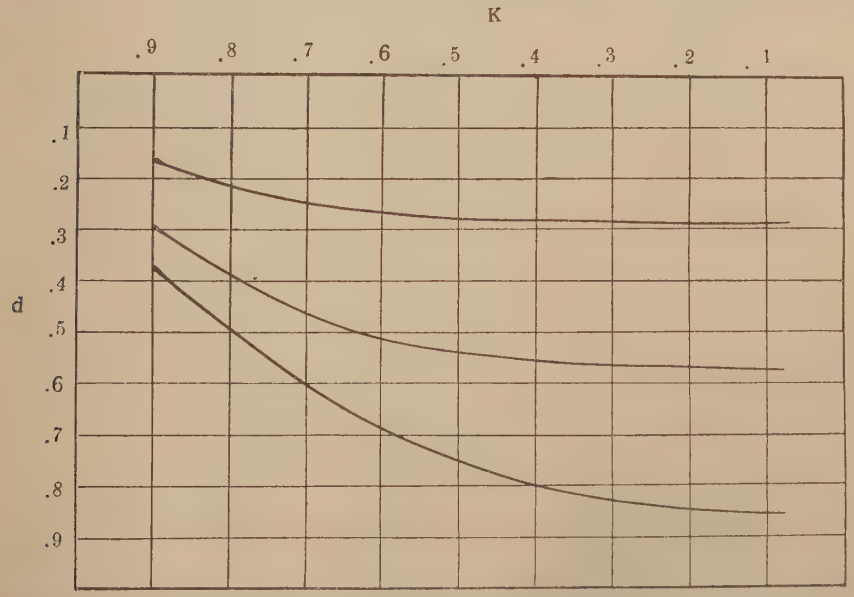


Fig. 4 (II). Relation between $d$ and $k$ when six hooks were used. Upper, middle and lower curves correspond to upper, middle and lower hook.

## 6. Results

1) Horizontal and vertical distributions

As a first example we shall treat the data on the catch of the South Pacific Ocean. From Table 4 we can demonstrate that the rate of exploitation by each

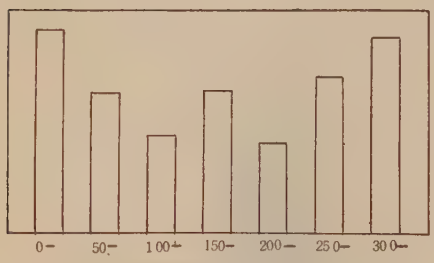


Fig. 5. Horizontal distribution along the main line. Ordinate; Number of fish caught, Abscissa; Number of basket.

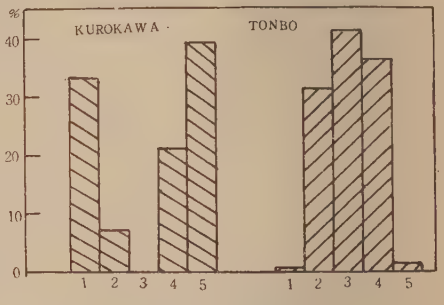


Fig. 6. Relation between the order of hook and rate of exploitation (%)

Table 4. Statistics of catch of Kurokawa and Tombo arranged in order of basket.

Although the number of basket used is 330, there are many hooks which did not catch fish. Therefore in the table, number of catch in each day is shown on 50 baskets. Various fishes other than Kurokawa and Tombo are also shown, but these fish were not used in the calculation. Numbers of Kurokawa and Tombo are shown in upper and lower lines respectively.

| No. of basket | Date | | | | | | | | | | | | | | | | | Total | | Grand total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | June | | | | July | | | | | | | | | | | | | Kuro-kawa | Tombo | |
| | 26 | 27 | 28 | 30 | 1 | 2 | 3 | 4 | 5 | 7 | 9 | 10 | 11 | 12 | 14 | 15 | 17 | | | |
| 0–49 | 4 | 3 | 2 | 4 | 3 | 4 | 1 | 2 | 3 | 4 | 3 | 2 | 0 | 3 | 0 | 0 | 2 | 40 | | 73 |
| | 4 | 2 | 2 | 0 | 3 | 3 | 2 | 2 | 2 | 3 | 3 | 0 | 3 | 1 | 2 | 0 | 1 | | 33 | |
| 50–99 | 6 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 2 | 23 | | 50 |
| | 2 | 1 | 2 | 2 | 2 | 5 | 0 | 2 | 1 | 1 | 1 | 0 | 2 | 2 | 2 | 0 | 2 | | 27 | |
| 100–149 | 0 | 1 | 0 | 2 | 1 | 0 | 0 | 1 | 1 | 3 | 2 | 0 | 0 | 1 | 3 | 2 | 1 | 18 | | 35 |
| | 1 | 1 | 0 | 1 | 4 | 3 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | | 17 | |
| 150–199 | 1 | 2 | 3 | 3 | 1 | 2 | 0 | 1 | 0 | 1 | 2 | 0 | 0 | 2 | 0 | 1 | 2 | 21 | | 51 |
| | 6 | 1 | 1 | 2 | 5 | 4 | 1 | 2 | 3 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | | 30 | |
| 200–249 | 1 | 2 | 2 | 2 | 1 | 1 | 0 | 0 | 1 | 3 | 0 | 2 | 0 | 1 | 1 | 1 | 0 | 18 | | 32 |
| | 6 | 1 | 2 | 0 | 1 | 1 | 0 | 0 | 3 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | | 14 | |
| 250–299 | 0 | 4 | 3 | 3 | 2 | 1 | 0 | 3 | 2 | 1 | 3 | 2 | 0 | 0 | 1 | 1 | 2 | 28 | | 56 |
| | 2 | 0 | 3 | 1 | 9 | 3 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 2 | | 28 | |
| 300–329 | 0 | 2 | 4 | 3 | 4 | 3 | 2 | 3 | 3 | 2 | 5 | 3 | 0 | 2 | 2 | 0 | 1 | 39 | | 70 |
| | 4 | 0 | 1 | 0 | 4 | 7 | 0 | 3 | 3 | 2 | 0 | 0 | 3 | 0 | 3 | 0 | 1 | | 31 | |
| Total | 11 | 15 | 16 | 18 | 14 | 12 | 5 | 11 | 10 | 15 | 17 | 9 | 0 | 10 | 8 | 6 | 10 | 187 | | 187 |
| | 22 | 6 | 11 | 6 | 28 | 26 | 4 | 11 | 14 | 9 | 6 | 0 | 12 | 7 | 10 | 0 | 8 | | 180 | 180 |
| Other fish | 12 | 11 | 0 | 0 | 8 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | 35 |
| Grand Total | 45 | 32 | 27 | 24 | 50 | 38 | 13 | 22 | 24 | 24 | 23 | 9 | 12 | 17 | 18 | 6 | 18 | | | 402 |

hook is high at both ends as shown in Fig. 5. This results show that the number of catch in the group of 50 baskets is the highest at both ends and moderately high at the middle part. Thus we have W-shaped distribution on the catch along the line. The same result was obtained in example *B* too, but there are other data which contradict our results. Hence we shall reserve the conclusion that our results holds generally.

The same data may be arranged in another way. In this example the number of hooks in one basket was 5, and in Table 5 the distribution of catch by each hook is shown. In this case the division points of the main line are $A_1, A_2, \ldots, A_5$ where $A_3$ is the deepest point. In Fig. 6 the abscissa corresponds to the division points $A_1, \ldots, A_5$ and the ordinate represents the rate of exploitation given in the last row of Table 5.

From Fig. 6 it is evident that the rate of exploitation changes very sharply according to the relative depths of hooks. If we know the value of $k$ we can determine the vertical distance between $A_3$ and $A_2$ (or $A_5$) and $A_3$ and $A_1$ (or $A_5$), from which we can change the scale of abscissa of this example into the absolute depth. While unfortunately in this example the value of $k$ is not given therefore the numerical values of depths of each hook could not be obtained, but in next example (B) we shall be able to use the value of $k$ in order to determine the absolute depth of hooks.

Table 5. Number of fish caught by each hook

| Number of basket | Order of hook | | | | | | | | | | Others | Total | | Grand Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Kurokawa | | | | | Tombo | | | | | | Kuro-kawa | Tombo | |
| | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | | | | |
| 0～ | 10 | 1 | 0 | 1 | 14 | 0 | 6 | 15 | 6 | 0 | 6 | 26 | 27 | 59 |
| 30～ | 7 | 1 | 0 | 2 | 8 | 0 | 3 | 4 | 3 | 0 | 5 | 18 | 10 | 33 |
| 60～ | 5 | 1 | 0 | 3 | 5 | 0 | 6 | 7 | 6 | 0 | 2 | 14 | 19 | 35 |
| 90～ | 2 | 0 | 0 | 2 | 5 | 0 | 2 | 3 | 4 | 0 | 0 | 9 | 9 | 18 |
| 120～ | 4 | 1 | 0 | 5 | 5 | 0 | 3 | 3 | 6 | 0 | 4 | 15 | 12 | 31 |
| 150～ | 4 | 0 | 0 | 1 | 4 | 0 | 5 | 7 | 2 | 0 | 3 | 9 | 14 | 26 |
| 180～ | 3 | 2 | 0 | 4 | 5 | 0 | 7 | 7 | 3 | 0 | 4 | 4 | 17 | 35 |
| 210～ | 3 | 0 | 0 | 3 | 6 | 0 | 0 | 3 | 3 | 2 | 1 | 12 | 8 | 21 |
| 240～ | 6 | 2 | 0 | 3 | 3 | 0 | 3 | 3 | 1 | 0 | 4 | 14 | 7 | 25 |
| 270～ | 6 | 2 | 0 | 6 | 5 | 0 | 10 | 9 | 7 | 0 | 3 | 19 | 26 | 48 |
| 300～ | 12 | 3 | 0 | 9 | 13 | 1 | 11 | 13 | 6 | 0 | 3 | 37 | 31 | 71 |
| Total | 62 | 13 | 0 | 39 | 73 | 1 | 56 | 74 | 47 | 2 | 35 | 187 | 180 | 402 |
| ‰ | 332 | 70 | 0 | 208 | 390 | 6 | 311 | 411 | 361 | 11 | | | | |

2) Absolute depth of hook and the change of fishing rate according to the depth of hook

In this example the approximate value of $k$ may be utilized. It was calculated from the relation (18). Suppose that the vessel starts at time $t_1$ with

Table 7. Data on fishing and fishing ground

| No. of Op. | Date | Taking and Setting of Line | | Position of Starting Point | | Speed of Vessel | Weather | Air Temp. | Surface Water Temp. | Direction and Force of Wind | Water Colour | No. of Basket (Cotton +Ramie) | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | N | E | km/hr | | °C | °C | | | | |
| 1 | Oct. 7 | 4/40–7/20 | 12/0 –18/0 | 39°19′ | 174°30′ | 4 | BC | 22.5 | 22.0–19.8 | S/W–3 | 2 | 170+0 | 170 |
| 2 | 8 | 3/0 –7/10 | 12/0 –2/20 | 37°29′ | 175°50′ | – | BC | 20.5 | 22.8–22.7 | NW–1 | 2 | 163+87 | 250 |
| 3 | 9 | 3/30–7/– | 12/30–23/– | 38°15′ | 175°48′ | 5 | C | 17.5 | 22.1 | NNE–1 | 2 | 180+120 | 300 |
| 4 | 10 | 6/20–9/30 | 14/– –24/– | 37°50′ | 177°10′ | 3 | R | 17.0 | 21.2 | E/S–4 | 2 | 〃 | 〃 |
| 5 | 12 | 3/– –6/30 | 11/30–21/30 | 38° 7′ | 178°20′ | 5 | R | 18.0 | 22.5 | SW/W–2 | 2 | 163+163 | 326 |
| 6 | 13 | 3/30–7/20 | 11/30–19/25 | 38°18′ | 178°35′ | 2 | BC | 19.5 | 21.8 | N/E–6 | 3 | 〃 | 〃 |
| 7 | 14 | 3/– –6/55 | 12/– –23/20 | 38°35′ | 178°55′ | 5 | B | 19.5 | 21.4 | NE–2 | 2 | 〃 | 〃 |
| 8 | 15 | 3/30–6/55 | 13/– –22/00 | 38°20′ | 178°52′ | 6 | R | 21.0 | 21.6 | SW–1 | 2 | 163+137 | 300 |
| 9 | 16 | 3/30–7/– | 12/– –22/00 | 37°50′ | 179°20′ | 6 | B | 21.0 | 21.4–21.0 | SE–1 | 3 | 163+163 | 326 |
| 10 | 17 | 3/30–6/50 | 13/00–20/50 | 37°25′ | 179°30′ | 6 | B | 22.5 | 21.5–21.8 | N–1 | 2 | 〃 | 〃 |
| 11 | 18 | 7/40–10/10 | 14/00–22/30 | 38°30′ | 179°35′ | 6 | B | 23.5 | 21.4–21.6 | S/E–1 | 2 | 176+104 | 280 |
| 12 | 19 | 6/00–9/10 | 14/00–22/20 | 38°40′ | 178°28′ | 6.5 | B | 22.0 | 21.5–21.8 | S/E–0.5 | 2 | –– | 300 |
| 13 | 20 | 3/30–6/20 | 11/30–13/00 | 38°40′ | 178°29′ | 4 | C | 22.0 | 21.5 | SSW–4 | 2 | 163+163 | 326 |
| 14 | 21 | 4/– –7/30 | 13/– –24/00 | 38°30′ | 178°30′ | – | BC | 18.0 | 20.9 | NNE–3 | 2 | 〃 | 326 |
| 15 | 23 | 2/50–6/20 | 12/00–22/30 | 37°12′ | 175°35′ | 5 | BC | 22.0 | 20.9–21.2 | SW–2 | 3 | 〃 | 326 |
| 16 | 24 | 3/– –6/50 | 12/00–23/00 | 37°10′ | 175°20′ | 5 | B | 22.0 | 21.2–22.4 | NSW–2 | 2 | — | 300 |
| 17 | 25 | 3/20–7/10 | 12/30–22/30 | 37°15′ | 175°15′ | 5 | B | 22.0 | 21.2 | SW–2 | 2 | — | 〃 |
| 18 | 26 | 3/00–6/40 | 12/30–22/30 | 37°20′ | 175°30′ | 5 | C | 22.5 | 21.2 | SSW–2 | 2 | — | 〃 |
| 19 | 27 | 3/30–6/55 | 12/30–21/10 | 37°20′ | 175°20′ | 5.5 | BC | 23.5 | 21.2 | SSW–2 | 2 | — | 〃 |
| 20 | 28 | 3/30–7/00 | 13/00–22/40 | 37°10′ | 175°45′ | 6.5 | B | 23.5 | 21.2–22.4 | SSW–1 | – | — | 〃 |
| 21 | 29 | 3/30–7/15 | 12/00–21/50 | 36°58′ | 176° 5′ | 4 | B | 23.5 | 21.2 | SSW–3 | 3 | — | 〃 |
| 22 | 30 | 3/40–7/40 | 13/00–24/20 | 37°10′ | 175°25′ | 6 | B | 21.5 | 21.5 | SSW–1 | 2 | — | 〃 |
| 23 | 31 | 4/00–8/00 | 12/00–24/50 | 36°55′ | 175°10′ | 6 | B | 19.5 | 21.0–22.1 | NNW–2 | 2 | 163+137 | 〃 |
| 24 | Nov. 1 | 3/00–7/00 | 12/30–21/50 | 36°50′ | 174°45′ | 3 | BC | 18.0 | 21.0–21.4 | NNW–4 | 2 | — | 270 |
| 25 | 2 | 3/00–6/40 | 10/30–22/40 | 37°10′ | 174°20′ | 6 | C | 16.0 | 21.0–20.8 | SW/W–1 | – | — | 300 |
| 26 | 3 | 5/00–8/20 | 11/20–21/20 | 37°10′ | 173°45′ | 5 | BC | 20.0 | 21.3–20.5 | NW/W–2 | 3 | — | 〃 |
| 27 | 6 | 2/40–7/00 | 12/00–22/30 | 37°15′ | 172°42′ | 6 | B | 16.0 | 20.9 | NNW–2 | 2 | — | 〃 |
| 28 | 7 | 2/30–7/10 | 12/30–21/35 | 37°00′ | 174°40′ | 6 | B | 17.0 | 19.8–20.2 | NNE–1 | 3 | — | 〃 |
| 29 | 9 | 5/00–7/50 | 11/00–21/30 | 37°15′ | 168°50′ | 4.5 | BC | 20.0 | 20.9–19.4 | NW–3 | 3 | — | 270 |
| 30 | 10 | 3/00–7/20 | 12/00– 3/00 | 36°55′ | 168°30′ | 4 | C | 14.0 | 19.2–20.1 | N–2 | 3 | — | 〃 |

the velocity $v$ km/hr and it stops at time $t_2$. During this period the vessel runs $v(t_2-t_1)$ km. If the length of the main line is $L$ and the number of used baskets is $N$, then the mean value of $k$ may be obtained from the formula

$$k=v(t_2-t_1)/NL \qquad (18)$$

as is shown in Table 6. Conditions of the fishing on each day and the direction

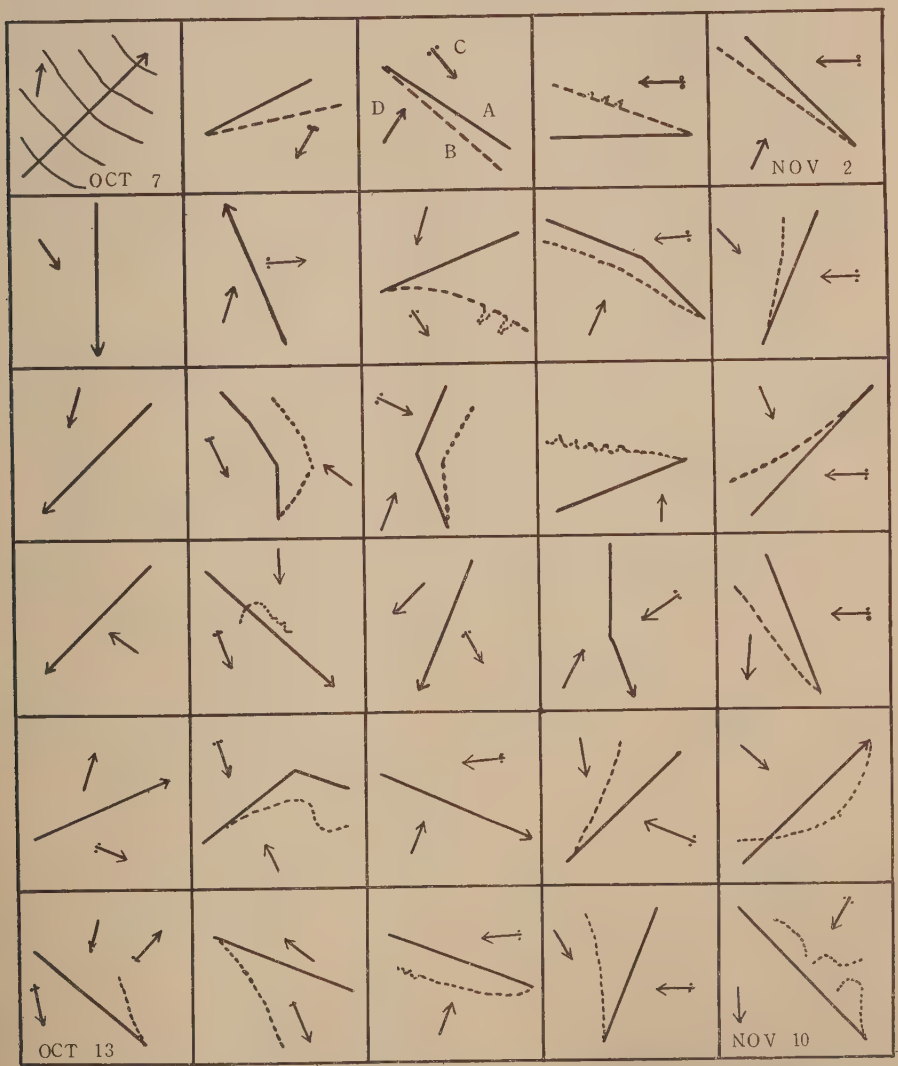


Fig. 7. Course of long-line. The course of the long-line were drawn by the figures given in Table 7 and figures prepared by Mr. Kamei. At first, the long-line is set as shown by A, during fishing it translate to B by current and wind which are shown by C and D.

Table 6. The distribution of the value of k

| k | 0.1–0.2 | 0.2–0.3 | 0.3–0.4 | 0.4–0.5 | 0.5–0.6 | Total | mean | Variance |
|---|---|---|---|---|---|---|---|---|
| Frequency | 1 | 3 | 11 | 9 | 4 | 28 | 0.388 | 0.01323 |

of the long line with the current drift are shown in Table 7 and Fig. 7.

Although the length of line and the number of baskets of the cotton main line and ramie main line is not equal, it is assumed, for the sake of simplicity, that the main line in one basket is of equal length in both kinds of material i.e. 300 meters. Therefore it should be noticed that the calculated value of $k$ is not exactly one, but as an approximate value it has sufficient accuracies.

Let the first half part of the line be $\alpha$ and the rest $\beta$. These two parts are constructed by the cotton and by the ramie and in each part one basket has 6 and 5 hooks respectively. As the specific weight of the ramie is large, the number of hooks in one basket is reduced for ramie.

In Table 8 the total catch of Tombo of each hook from No. 1 to No. 6 is

Table 8. Number of fish caught by the long line.

| Name of fish | No. of hook | No. of line α 0– | 30– | 60– | 90– | 120– | Total in cotton line | No. of line β 150– | 180– | 210– | 240– | 270– | Total in Ramie line | Grand Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOMBO | (1) | 5 | 6 | 3 | 4 | 4 | *22* | 2 | 1 | 5 | 3 | 2 | *13* | **35** | |
| | (2) | 13 | 7 | 5 | 10 | 5 | *40* | 7 | 3 | 5 | 3 | 6 | *24* | **64** | |
| | (3) | 12 | 11 | 7 | 3 | 5 | *38* | 3 | 4 | 4 | 9 | 12 | *32* | **70** | |
| | (4) | 5 | 12 | 2 | 4 | 6 | *29* | 6 | 2 | 2 | 6 | 5 | *21* | **50** | |
| | (5) | 6 | 15 | 1 | 5 | 2 | *24* | 5 | 3 | 4 | 5 | 2 | *19* | **43** | |
| | (6) | 4 | 5 | 0 | 3 | 0 | *12* | 1 | 0 | 0 | 0 | 1 | *2* | **11** | 276 |
| BACHI | (1) | 3 | 0 | 0 | 0 | 0 | *3* | 0 | 0 | 0 | 1 | 1 | *2* | **5** | |
| | (2) | 19 | 4 | 1 | 1 | 6 | *31* | 3 | 4 | 3 | 4 | 2 | *16* | **47** | |
| | (3) | 26 | 11 | 3 | 1 | 9 | *50* | 3 | 4 | 4 | 6 | 5 | *22* | **72** | |
| | (4) | 14 | 10 | 6 | 5 | 6 | *41* | 3 | 4 | 5 | 6 | 7 | *25* | **66** | |
| | (5) | 8 | 5 | 0 | 6 | 4 | *23* | 1 | 2 | 1 | 2 | 4 | *10* | **33** | |
| | (6) | 1 | 0 | 0 | 0 | 0 | *1* | 0 | 0 | 0 | 0 | 0 | *0* | **1** | 224 |
| AOTA | (1) | 5 | 3 | 0 | 3 | 2 | *13* | 3 | 4 | 0 | 6 | 3 | *16* | **29** | |
| | (2) | 11 | 3 | 4 | 3 | 3 | *24* | 2 | 4 | 3 | 6 | 13 | *28* | **52** | |
| | (3) | 4 | 9 | 2 | 3 | 3 | *21* | 2 | 1 | 1 | 8 | 6 | *18* | **39** | |
| | (4) | 2 | 0 | 3 | 3 | 1 | *9* | 1 | 2 | 0 | 1 | 7 | *11* | **20** | |
| | (5) | 6 | 0 | 2 | 2 | 2 | *12* | 2 | 1 | 1 | 4 | 5 | *13* | **25** | |
| | (6) | 1 | 1 | 3 | 1 | 0 | *6* | 0 | 0 | 0 | 0 | 0 | *0* | **6** | 171 |
| KAJIKI | (1) | 8 | 8 | 5 | 2 | 3 | *26* | 3 | 4 | 2 | 3 | 3 | *15* | **41** | |
| | (2) | 1 | 3 | 2 | 0 | 2 | *8* | 0 | 1 | 2 | 3 | 2 | *8* | **16** | |
| | (3) | 1 | 0 | 0 | 0 | 1 | *2* | 2 | 1 | 4 | 5 | 5 | *17* | **19** | |
| | (4) | 2 | 0 | 1 | 0 | 0 | *3* | 0 | 0 | 2 | 8 | 5 | *15* | **18** | |
| | (5) | 5 | 1 | 2 | 1 | 2 | *11* | 0 | 3 | 1 | 3 | 2 | *9* | **20** | |
| | (6) | 3 | 5 | 1 | 5 | 0 | *14* | 1 | 0 | 0 | 0 | 0 | *1* | **15** | 192 |
| Total | | 165 | 114 | 53 | 65 | 66 | | 50 (60) | 48 (58) | 49 (59) | 92 (110) | 98 (118) | | **800** | 800 |

N.B. i) Catches of No. 6 hook by ramie main line are recorded erroneously during busy operation on the ocean but are enclosed according to the original record.

ii) Figures in branket in the column $\beta$ are the reduced figures when six hooks were used.

22, 40, 38, 29, 24 and 12 in the case of the cotton line while 13,...,2 in the case of the ramie line. Hence the relative abundance of Tombo in each layers are

$$(22+12):(40+24):(38+29)=34:64:67=0.211:0.386:0.404$$

as hooks No. 1 and No. 6, No. 2 and No. 5, No. 3 and No. 4 are situated at the same level. Similarly we can get relative abundance of other species at different depths on two kinds of material of the main line. These values are summarized as Table 9.

Table 9. Percentage of catch for each hook at various positions of line.

| Tombo | | Bachi | | Aota | | Kajiki | | Depth of hooks (m). | |
|---|---|---|---|---|---|---|---|---|---|
| α | β | α | β | α | β | α | β | α | β |
| 0.211 | 0.291 | 0.033 | 0.160 | 0.224 | 0.337 | 0.636 | 0.334 | 92.2 | 98.6 |
| 0.386 | 0.410 | 0.363 | 0.547 | 0.424 | 0.454 | 0.288 | 0.320 | 133.5 | 146.8 |
| 0.404 | 0.291 | 0.611 | 0.293 | 0.354 | 0.209 | 0.075 | 0.220 | 170.6 | 169.2 |

In order to get the depth of the position of hooks we shall at first calculate the value of $\varphi_0$. Using the value of $k=0.388$ we get $\varphi_0=81°31'$ by means of the relation (15) or by Fig. 3. Hence putting $a=l\cdot\tan\varphi_0=150\times0.1475=22.43$, the coordinates of the hook at the point $A_j(x_j, y_j)$ may be obtained. On the other hand the total length of the branch line and floating line is 50 meters. Thus the depth of each hook under the water surface is obtained as shown in Figure 8. These calculations were carried out in the preliminary report (1951) but by the diagram which is given in this paper we may easily obtain the results.

3) Other results obtained from published data

From January 1951 to April 1952 six cruises of the exploratory vessel "Sagamimaru" were undertaken by the Kanagawaken Fishery Experiment Station. The results of the investigations were published in a series of reports (1951–2), from which the values of $k$ may be obtained. At each operation, the positions of two end points of the main line were given, hence we can obtain the distance of these two points by plotting them on a section paper. Let the length of the main line be $L$, number of basket $N$ and the distance of two end points $D$, then the value of $k$ may be given by the formula

$$k=D/NL=NkL/NL\ . \quad (19)$$

But unfortunately it was found that not only the calculated values were too high but also it often exceeded the unity (by definition the value of $k$ must be less than unity). Hence we

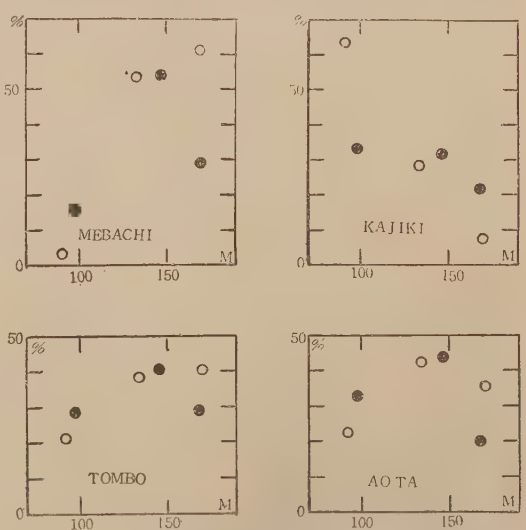


Fig. 8. Relations between the depth of position of hook and fishing rate. α: (○), β: (●).

can not discuss the vertical distribution depending on these figures. Thus we shall not attempt further analysis although the original reports contain many useful factors which seem to influence the fishing rate of the long-line fishery.

Usually the position finding of a small fishing vessel on the ocean is difficult and the figures obtained are not exact, hence the determination of the value of $k$ by the formula (19) is not exact although it is very convenient one.

In the same series of the reports there is given the number of catch of several species of fish which were caught by the hook at various water layers, and they are grouped into three classes $A, B$ and $C$. The symbols $A$, $B$ and $C$ represent the number of fish caught by hooks which are set at various positions in the sea and the figures of Table 10 show the total number of fish caught by the hooks No. 1 and No. 6 (or No. 5) in the case $A$, No. 2 and No. 5 (or No. 4) in the case $B$ and No. 3 and No. 4 (or No. 3 only) in the case $C$ (when 5 hooks are used the figures in the basket should be used). Numbers in the class $A$ represent the fish caught in the shallow water layer and numbers in the class $C$ represent the fish caught in the deep water layer. As the value of $k$ was not determined in this investigation, the abosolute depths of the layers $A, B$ and $C$ could not be determined but it is evident that the figures in the

Table 10. The catch of various fishes in shallow, middle and deep water layers determined from the records obtained in six voyages of exploratory vessel "Sagamimaru" from January 1951 to April 1952

| Name of fish | | Kihada | | | | Total | Mebachi | | | | | | Total | Kurokawa | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. of cruise | | 1. | 2. | 3. | 4. | | 1. | 2. | 3. | 4. | 5. | 6. | | 1. | 2. | 3. | 4. | |
| No. of fish in each water layers | A | 152 | 210 | 290 | 53 | 705 | 19 | 26 | 123 | 29 | 24 | 89 | 310 | 74 | 61 | 208 | 42 | 388 |
| | B | 442 | 396 | 456 | 156 | 1450 | 78 | 49 | 242 | 133 | 37 | 133 | 672 | 103 | 60 | 172 | 114 | 499 |
| | C | 916 | 639 | 721 | 133 | 2409 | 156 | 87 | 372 | 166 | 20 | 60 | 861 | 148 | 79 | 168 | 113 | 508 |

| Name of fish | | Yoshikiri | | | | | | Total | Hiragashira | | | Total | Tombo | | Total | Mekajiki |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. of cruise | | 1. | 2. | 3. | 4. | 5. | 6. | | 2. | 3. | 4. | | 5. | 6. | | 6. |
| No. of fish in each water layers | A | 18 | 14 | 72 | 5 | 28 | 97 | 234 | 24 | 141 | 39 | 204 | 399 | 50 | 449 | 53 |
| | B | 28 | 20 | 104 | 37 | 32 | 106 | 327 | 25 | 80 | 68 | 173 | 688 | 105 | 793 | 52 |
| | C | 51 | 32 | 94 | 31 | 30 | 66 | 304 | 14 | 24 | 67 | 155 | 441 | 58 | 499 | 17 |

| No. of cruise | 1 | 2 | 3 | 4 | 5 | 6 | Total |
|---|---|---|---|---|---|---|---|
| Date | 1951 Jan.-Mar. | 1951 April-May | 1951 July-Sept. | 1951 Sept.-Nov. | 1952 Jan.-Feb. | 1952 Feb.-April | |
| Fishing ground | N 2–6° E158–161° | 0–6° 154–162° | 2–10° 160–180° | 0–10° 165–180° | 28–35° 153–173° | 27–32° 170–180° | |
| No. of operation | 25 | 19 | 39 | 18 | 16 | 16 | 133 |
| Total number of baskets used | 8251 | 6277 | 13069 | 6343 | 4619 | 4822 | 48381 |
| No. of hooks in one basket | 6 | 6 | 6 | 5 | 5 | 5 | |

Table 10 show the general tendencies that the fishing rate of Kihada and Mebachi are large in the deep water layers and in Tombo the maximum rate of fishing appears in the middle water layer (Fig. 9). These results do not contradict with the conclusion given in the preceding section.

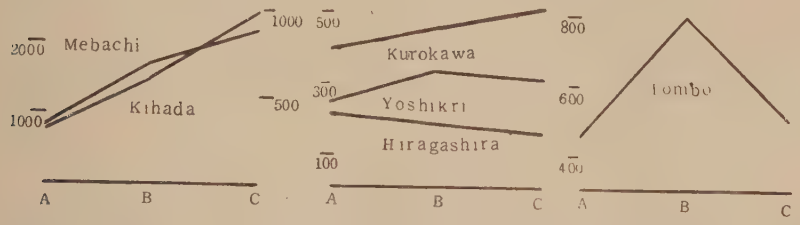


Fig. 9. Change of the rate of exploitation in accordance with the depth of hook.

## 7. Discussion

1) Distributions of the swimming depth

In the example *A* we know that the great parts of Kurokawa and Tombo were caught in the shallow and the deep water layers respectively. Similarly in Fig. 8 of example *B*, it was found that the rate of exploitation was high at the deep layer on Bachi, while most of Kajiki were caught in the shallow water layer and the maximum rate of exploitation was found between 100–150 meters on Tombo and Aota.

The optimum temperature of tuna has been investigated by Uda (1935). He stated that owing to the lack of observations both of the accurate depth and of temperature of the layer in which tuna are angled with long-line, reference being made only to the surface temperature. Estimation of temperature without direct observation can yet be made by calculating preliminarily the difference between the surface temperature and swimming layer from other serial observations of temperature for each region and for month, provided the accurate depth is known. From the records of the surface temperature, the temperature of swimming layers was calculated, with the results that the mode of total catch lies at about 18°C, the values of swimming depth having been taken as 50 to 100 meters.

The optimum temperature and the swimming layers which maximum catch may be expected will be vary in each fishing ground. Therefore the discrepancies between his conclusions and of this paper can not be discussed without the modification by other factors.

I have tried to estimate the temperature of swimming layers from the decreasing rate of temperature but as the change between the temperatures of upper layer and of lower layer is sometimes very irregularily this aspect have been postponded to the following paper.

Mulichi (1948) investigated the horizontal and vertical distributions of sprat which were caught by drift nets at different depths. In Fig. 3 of his paper the density of sprats in the different water layer during summar is shown. From

these results we know that if sufficient number of gears are set in different water layers the density of catch of each species will represent an unimodal distribution. As another example the vertical distribution of oyster is given by Chestnut and Fahy (1952) but the details of the results seem to be unpublished. We shall assume that it may be represent by the normal distribution curve which has its mean depth at $\bar{x}_i$ meters beneath the surface and the variance $\sigma^2$.

According to the definition, the temperature of the layer at depth $\bar{x}_i$ is the optimum temperature and this will vary by various factors e.g. species, seasons, current, localitity of fishing ground, shape of bottom, depth of swimming layer etc.

There is a report on the relation between the swimming depth and the distance from shore in North Pacific salmon fishery. Sugano (1936) found that when the number of salmons which were found gilled on the leading branch of fixed nets which is installed at Voroskaya, West Kamtchatka was analysed with respect to the distributions in the depth below the water surface, in distance from sea-shore and in the direction, the factors of migration routes of the fish were inferred, but in this example the number of fish gilled decreased with the distance from the water surface and there is no optimum depth which the number of fish caught is maximum. Recently Maeda (1953) analysed the distribution of fishes on the gill net.

Suppose that there are two species in the fishing ground and their mean swimming depths are $\bar{x}_1$ and $\bar{x}_2$ respectively. If we want to catch these two species by single gear we have to adjust the value of $k$ so as to catch both species effectively.

Take a hypothetical mean depth $\bar{x}$ and assume that $\bar{x}+r$ and $\bar{x}-r$ represent the highest and lowest positions of hooks. If $N_i(i=1, 2)$ represents the total catch of $i$-th species when hooks extend uniformly from the water surface to the bottom of the sea and the vertical distribution of fish is normal then the mean catch $n_i$ for the depth $(\bar{x}+r, \bar{x}-r)$ will be shown by the integral

$$n_i=N_i\int_{\bar{x}-r}^{\bar{x}+r} f_i(x)dx \qquad \text{where} \qquad f_i(x)=\frac{1}{\sqrt{2\pi}\,\sigma_i}\exp\left(-\frac{(x_i-\bar{x})^2}{2\sigma_i{}^2}\right).$$

Hence if $x=\bar{x}$ is the value which make the sum $n=n_1+n_2$ maximum, then $\bar{x}$ is the mean depth which yield the maximum total catch on the two species by a single gear. To get $\bar{x}$ we have to solve the equation $dn/d\bar{x}=0$.

In a recent report, Murphy and Shomura (1953:26) stated that "It is of considerable biological and commercial importance to know that at what depth the deep-swimming tunas are most abundant. Several Japanese workers (e.g. Nakamura 1943, Ochi 1952) take notice that the catch rate of yellow fin and bigeye tuna is higher on the deeper fishing hooks though they have been unable to ascertain the precise level at which the hooks were fishing", "The construction of the P. O. F. I. (Pacific Oceanic Fishing Investigation) long line gear permits classifying the hooks according to these depth level. The potential depths that these levels can attain is fixed by the distance between bouys". They determined the depth of the main line by the diagram constructed by T. Cromwell. He attached putty balls at regular intervals to a line and hung it from a skiff with

Table 11. Vertical distribution of fish

| Name of fish | No. of hook | No. of operation | | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | |
| Bachi | 1 | 0 | 0 | 7 | 4 | 4 | 1 | 2 | 0 | 1 | 3 | 3 | 3 | 1 | 29 |
| | 2 | 4 | 1 | 11 | 13 | 4 | 1 | 1 | 3 | 4 | 2 | 5 | 5 | 3 | 57 |
| | 3 | 5 | 6 | 12 | 6 | 7 | 1 | 2 | 2 | 7 | 6 | 5 | 5 | 4 | 68 |
| | 4 | 6 | 2 | 10 | 5 | 2 | 0 | 2 | 2 | 0 | 5 | 2 | 3 | 3 | 42 |
| | 5 | 1 | 1 | 4 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 | 11 |
| Kihada | 1 | 0 | 0 | 0 | 0 | 0 | 17 | 5 | 2 | 5 | 7 | 8 | 10 | 12 | 68 |
| | 2 | 1 | 1 | 4 | 0 | 0 | 39 | 14 | 26 | 16 | 10 | 19 | 10 | 21 | 161 |
| | 3 | 3 | 0 | 2 | 1 | 0 | 54 | 22 | 35 | 17 | 16 | 23 | 10 | 33 | 215 |
| | 4 | 0 | 0 | 3 | 0 | 1 | 36 | 21 | 18 | 17 | 11 | 16 | 16 | 20 | 159 |
| | 5 | 0 | 0 | 1 | 0 | 0 | 22 | 6 | 7 | 9 | 10 | 4 | 6 | 8 | 73 |
| Kurokawa | 1 | 3 | 1 | 5 | 5 | 3 | 3 | 2 | 3 | 2 | 3 | 1 | 3 | 4 | 38 |
| | 2 | 7 | 5 | 2 | 3 | 6 | 4 | 3 | 4 | 2 | 5 | 5 | 1 | 2 | 55 |
| | 3 | 5 | 2 | 4 | 5 | 7 | 2 | 2 | 6 | 7 | 6 | 2 | 51 | 1 | 52 |
| | 4 | 9 | 5 | 4 | 3 | 5 | 4 | 2 | 1 | 6 | 6 | 4 | 0 | 7 | 56 |
| | 5 | 5 | 0 | 3 | 2 | 7 | 0 | 3 | 6 | 4 | 9 | 4 | 4 | 10 | 57 |
| Katsuwo | 1 | 1 | 6 | 2 | 5 | 2 | 8 | 0 | | | | | | | 24 |
| | 2 | 1 | 6 | 4 | 1 | 4 | 8 | 0 | | | | | 1 | | 22 |
| | 3 | 2 | 4 | 2 | 5 | 0 | 9 | 1 | | | | | | 1 | 24 |
| | 4 | 0 | 4 | 2 | 7 | 2 | 5 | 0 | | | | | | | 20 |
| | 5 | 1 | 2 | 1 | 6 | 1 | 6 | 2 | | | | | | | 20 |
| Same | 1 | 4 | 2 | 4 | 3 | 2 | 4 | 3 | 4 | 5 | 6 | 1 | 1 | 4 | 43 |
| | 2 | 6 | 4 | 5 | 3 | 10 | 6 | 5 | 3 | 0 | 5 | 1 | 3 | 8 | 59 |
| | 3 | 10 | 4 | 8 | 4 | 5 | 0 | 4 | 8 | 3 | 1 | 4 | 2 | 3 | 56 |
| | 4 | 5 | 4 | 5 | 6 | 3 | 3 | 4 | 3 | 7 | 5 | 2 | 2 | 3 | 52 |
| | 5 | 2 | 1 | 6 | 3 | 10 | 4 | 4 | 4 | 2 | 3 | 1 | 3 | 5 | 48 |

| Date | | Oct. 8 | 11 | 12 | 13 | 14 | 16 | 17 |
|---|---|---|---|---|---|---|---|---|
| Location | N | 10–56 | 10–06 | 8–40 | 7–16 | 8–31 | 4–46 | 4–04 |
| | E | 171–28 | 178–06 | 179–17 | 179–05 | 178–30 | 176–46 | 176–29 |
| Water temp. (°C) | 0 m | 28.70 | 28.40 | 28.40 | 28.50 | 28.8 | 28.60 | 28.60 |
| | 50 m | 28.30 | 27.96 | 27.81 | 28.31 | 28.05 | 28.50 | 28.40 |
| | 100 m | 22.05 | 22.17 | 22.41 | 21.20 | 21.20 | 27.90 | 27.60 |
| | 150 m | | | | 15.35 | 12.22 | 24.50 | 26.47 |
| | 200 m | 11.60 | 11.82 | 10.47 | 10.84 | 10.65 | 14.90 | 14.59 |
| | 300 m | 10.40 | 9.85 | | | | | |

| Date | | 18 | 19 | 20 | 21 | 22 | 23 |
|---|---|---|---|---|---|---|---|
| Location | N | 3–43 | 3–24 | 3–19 | 3–25 | 3–07 | 4–02 |
| | E | 175–20 | 174–26 | 173–45 | 173–42 | 173–54 | 174–51 |
| Water temp. (°C) | 0 m | 28.80 | 28.70 | 28.50 | 29.10 | 30.00 | 29.60 |
| | 50 m | 28.48 | 28.49 | 28.30 | 28.40 | 28.46 | 28.50 |
| | 100 m | 28.39 | 28.28 | 18.19 | 28.25 | 27.86 | 28.40 |
| | 150 m | 16.24 | 26.77 | 27.55 | 27.29 | 26.75 | 25.34 |
| | 200 m | 15.17 | 13.69 | 24.86 | 17.13 | 15.21 | 13.85 |
| | 300 m | | | | | | |

a heavy weight to keep it vertical. The skiff was then drifted over the center of the main line. The sounding line was then retrieved and the position of the shallowest dislodged putty ball noted. The results is given as Figure 5 in Murphy and Shomura. In this case the length of main line is 1260 feet and 5 hooks were used thus the theoretical depths reached by the hooks at various bouy distances may be calculated by the Fig. 4 of this paper.

The bouys they used were generally between 700 to 900 feet apart. Utilizing their diagram it was found that the hooks could have been fishing at approximately the following depths:

Shallow layer 310 to 320 feet, Intermediate layer 450 to 490 feet, Deep layer 540 to 560 feet.

Because of the exact level of the hooks is not known, the hook positions on the long-lines are taken as an indication of relative depth. They tested the goodness of fit of the observation by the chi-square analysis. The results show very clearly that the deep hooks generally caught more bigeye and yellowfin, although the shallow fishing gear used did not show this tendency some times.

2) Direct determination and the range of the depth of hook

Based on the results published by the Shizuokaken Fishery Experimental Station we can get the depth of hook directly. Between Sept. 25 and Nov. 11, 1952 the investigations were undertaken to determine the depth of hook by the exploratory vessel "Fujimaru". In this experiment each basket had five hooks and the distribution of fish caught are shown in Table 11 according to the rank of hook. The fishing ground extended between Lat. N. 3°–10° and Long E. 170°–180° and the position in each operation are shown in Figure 10, from which we can understand that there are two regions of fishing grounds. They are composed of one group of operations No. 1–No. 5 and other group of No. 6–No. 13. The vertical distributions of water temperature decreases uniformly from the layer of 50 meters and deeper in the first region while in the second it decreases gradually (Fig. 11). From Table 11 we know that Katsuwo is caught mainly in the first region and Kihada in the second region. Bachi and Kihada are caught by the deepest hook and Kurokawa, Katsuwo and Same (Shark) are caught evenly from the surface to the deeper layer.

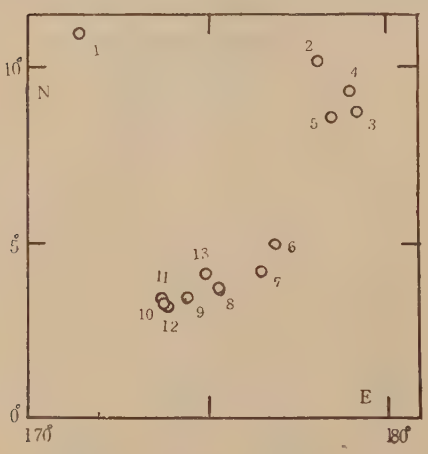


Fig. 10. Location of fishing ground of Fujimura, figures in the diagram show the number of operations.

About 40 hooks were selected to determine the position of them by means of the chemical tube. Judged by the results obtained, the upper hook is distributed from 70 to 90 meters deep, the middle hook from 100 to 135 meters deep and the lower hook from

120 to 145 meters deep. Unfortunately data which enable us to determine the hook depth i.e. values of $k$, are not given in the original report, therefore we can not discuss the relation between the slackness of the main line and the depth of the hook. But on referring to the data of Table 11 and the mean depth of each hook given above, we may draw lines representing the relation between the depth of hook and the percentage of catch by each hook. In Fig. 12 three lines are drawn. Two of them are the lines of Bachi and Kihada of Table 11 and the rest is a line drawn on the basis of figures given in Table 8. Besides the former lines water temperature at each depth is given.

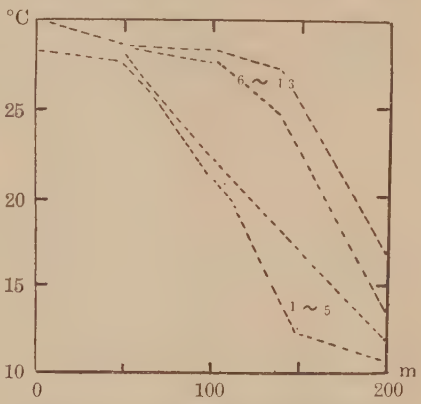


Fig. 11. Vertical distribution of water temperature in each region of fishing grounds.

We can get two conclusions from these relations:

The first is similarity of change of fishing rate at each depth on two experiments. In comparison with the data of Kuroshiomaru and of Fujimaru we know that each regression line is paralell. If we had the line of Fujimaru about 15 meters lower these two sets of lines would coincide. Thus this result show that as to the catch of Bachi, the increase of one meter of the depth of the main line results in the increase of catch about 0.8 percent of the total catch. The data given by the Mie Fishery Experimental Station (1952) show a very similar result.

In the second place we can demonstrate that, although in the experiment carried out by Kuroshiomaru the direct measurement of the depth of the position of hook had not attempted, the calculated depth of the hook was approximately correct in compared with the results of Fujimaru. From the data obtained by Fujimaru the mean water temperature of each water layer does not suggest the existence of the optimum water temperature in the case of Bachi in these two experiments, because the deepest hook at the water layer of 25° to 27°C made about 50 percent of the catch while only 15 percent of the total catch were made by the upper hook situated at water layer of about 28°C and the difference of water temperature between two layers is very small. Consequently we may judge that the catch of Bachi can not be determined only by the water temperature and they might like deep and dark layer, otherwise this results will be an exceptional case.

The lower line in Fig. 12 is drawn on the basis of the figures given in Tables 8 & 9 which are obtained as a mean values. Therefore the range of the depth of each hook is not determined but in Table 6 the variance of the value of $k$ is given as $0.115^2=0.01323$ and the distribution of the value of $k$ is approximately normal, hence about 95% of the values of $k$ lies within the range

$\bar{k}\pm 2\sigma_k = 0.388 \pm 2\times 0.115 = 0.163 - 0.623$.

From Figure 4 we get as the value of $d$ (in unit of $l$, i.e. half length of main line)

upper hook; 0.285, 0.270
middle hook; 0.575, 0.510
lower hook; 0.850, 0.680

and the length of the main line is about 300 meters. Thus depth of each hook may be obtained by multiplying these factors to $l=300/2=150$ and add the total length of the branch line and the floating line i.e. 50 meters. These values are (in unit of meter)

upper hook; 92.7, 90.5
middle hook; 136.3, 126.5
lower hook; 177.5, 152.5.

By connecting these points in Fig. 12 a confidence belt may be obtained. (But it was omitted). We may conclude from these results that the relation between the depth of hook and the rate of fishing may be obtained with a slight error by means of the mean value of $k$ with considerable variance provided that the method of determination of the values of $k$ is correct.

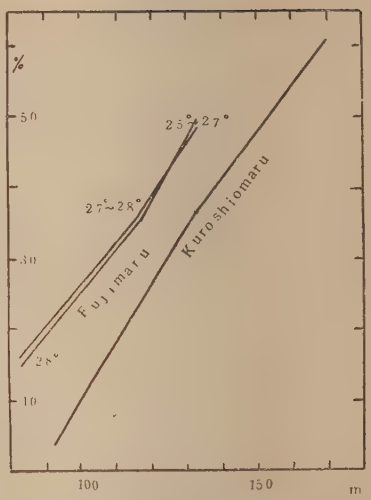


Fig. 12. Relation between the depth of swimming layer of Kihada and Bachi and water temperature.

3) Shape of the main line during the fishing

In another voyage of Fujimaru many trials on the determination of hook depth by chemical tube were carried out. From the results given in original report we may infer that the main line does not hold exactly the form of the catenary. The depths of No. 1, No. 2 and No. 3 hooks were 98, 135 and 140 meters respectively. From these values vectical differences of each hook may be obtained. They are 135−98=37, 140−135=5 and 140−98=42 meters respectively. Dividing these values by $l=270/2=135$ meters we have the values of 0.274, 0.037 and 0.311. From Fig. 4 we have the value 0.274 as the vertical difference of the hook No. 1 and No. 2 when the value of $k$ is about 0.6, but the value obtained from the difference between depths of No. 2 and No. 3 hooks is 0.037 which is too small and corresponds to the $k$-value beyond the range from 0.1 to 0.9. If we assume the last value 0.311, the value of $k$ becomes about 0.75. We can not judge whether the ture $k$-value is 0.6 or 0.7, as there is not given the value of $k$ in the original paper. In the event, the shape of the main line in the water seem to be a flat curve rather than the catenary. Accordingly the depth of hook obtained by the method of this paper might be too large for deeper hook.

## Summary

1. Data are presented on the distribution ot catches of tunas by the long-line gear.

2. Brief explanation on the method of fishing by the long-line gear was given.

3. A method has been proposed to estimate the depth of hooks attached on the division points of the main line.

4. Tables and diagrams to facilitate the calculations of the depth of hook were given.

5. The horizontal and vertical distributions of the catches by long-line were investigated.

6. The vertical distribution of tuna extend from surface to about 150 meters in depth according as the species. These values were obtained from the position of hooks, hunged from the main line, calculated by means of formulae based on the slackness of the main line.

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# MOVING OF A PIECE OF NET WITH FLOAT AND SINKER, AND CHANGING ITS FORM WHEN ITS LEAD LINE IS PULLED HORIZONTALLY BY A CONSTANT FORCE

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and Yosinori Nakai

(Received May 20, 1954)

In the present experiment, a 72 cm × 45 cm piece of net (mesh: 0.64 cm, diameter of cord: 0.07 cm) is supported vertically with float (buoyancy: 44.0 g) and sinker (weight in water: 6.55 g) in water and next the weight is set to fall freely as shown Fig. 1.

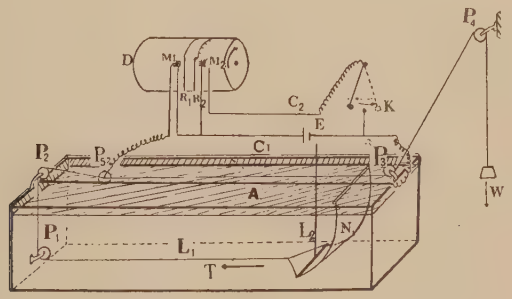


Fig. 1. Sketch of the apparatus used for the experiment.

| | | |
|---|---|---|
| $N$ | : | a piece of net, $P_{1\sim4}$: fixed pulley |
| $L_1$ | : | a string connecting weight $W$ and the lead line of net $N$ |
| $L_2$ | : | vertical scale attached to lead line |
| $P_5$ | : | a pulley driven by string $L_1$ on enamel wire $A$ |
| $M_1$, $M_2$ | : | electromagnets moving pens to mark $R_1$, $R_2$ on drum $D$ |
| $E$ | : | battery, $C_1$, $C_2$: leading wire, $K$: metronome. |

The movement of sinker line was studied by tracing the position of pulley $P_5$ on enamel wire $A$, and that was performed by striping the wire of its cover a few millimeter at 10 cm intervals. The changing of the form of net was studied by measuring the depth of lead line with the scale $L_2$.

Comparing the records $R_1$ and $R_2$, we calculated the time when the lead line moved some distance under the action of various weights.

The results thus obtained are summalized in table 1 and fig. 2.

In table 1 and fig. 2, we see that the lead line moved at a constant speed after a few second, because the float line was seemed to start at a few second after the weight was set free and it is considered that moved in an unchanging form at that constant speed, by the observation.

Fig. 3 and table 2 give such constant speed under the action of various weights.

Table 1. The time (in second) when the lead line moved following distance (in centimeter).

| Distance (cm) / Weight (g) | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | 110 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 22.9 | 2.5 | 3.7 | 6.6 | 10.1 | 13.6 | 16.6 | 20.0 | 23.3 | 27.3 | 30.7 | 34.2 |
| 31.4 | 0.5 | 1.0 | 3.2 | 5.5 | 8.1 | 11.1 | 13.8 | 16.4 | 19.3 | — | — |
| 40.0 | 1.3 | 3.3 | — | — | 10.5 | — | — | 17.2 | — | 22.0 | 24.8 |
| 48.5 | 0.5 | — | 2.6 | — | — | 10.4 | — | — | 19.3 | 21.0 | 23.5 |
| 57.1 | 0.3 | 0.8 | 2.5 | 4.0 | 5.6 | 7.4 | — | 12.0 | 14.0 | 15.6 | 17.6 |
| 65.7 | 0.7 | 4.1 | 4.5 | 5.0 | 7.5 | 9.5 | 10.7 | 12.0 | 13.9 | 15.5 | — |
| 73.2 | 0.6 | 1.7 | 3.1 | 4.5 | 6.2 | 8.1 | 9.9 | 11.4 | 13.2 | 15.0 | 17.6 |
| 82.8 | 2.5 | — | 3.5 | 4.5 | 5.2 | 7.5 | 8.1 | 9.4 | 10.4 | 11.7 | 12.9 |
| 91.3 | 1.0 | 2.0 | 3.2 | 4.5 | 5.5 | — | 8.0 | 8.8 | 9.6 | — | 12.0 |
| 99.9 | 0.5 | — | 2.0 | 3.0 | 3.9 | 5.2 | 6.4 | 7.6 | 9.0 | 10.5 | 11.5 |

| 120 | 130 | 140 | 150 | 160 | 170 | 180 | 190 | 200 |
|---|---|---|---|---|---|---|---|---|
| 38.0 | 41.5 | 45.5 | 50.0 | — | 56.5 | 59.8 | 63.9 | 67.2 |
| 27.0 | 30.9 | 33.3 | 35.8 | 39.7 | 42.8 | — | — | — |
| — | 31.0 | 33.5 | — | — | — | — | 47.5 | 48.4 |
| 26.6 | 30.0 | 33.2 | 36.1 | 39.0 | 41.6 | 44.5 | — | — |
| — | 20.6 | 23.0 | 25.2 | — | — | — | — | — |
| — | 22.5 | — | 26.5 | 29.2 | 31.0 | 32.8 | 34.5 | 35.5 |
| 19.8 | 21.4 | 23.0 | 24.6 | 25.7 | 27.7 | 29.2 | 30.6 | 32.5 |
| 14.5 | 16.0 | 16.8 | 18.6 | 19.5 | 20.5 | 22.4 | 23.6 | 25.0 |
| — | 14.1 | 14.7 | — | 17.0 | 18.2 | 19.2 | — | 21.2 |
| — | 13.8 | 14.5 | 15.7 | 17.0 | 18.7 | 19.4 | — | 21.4 |

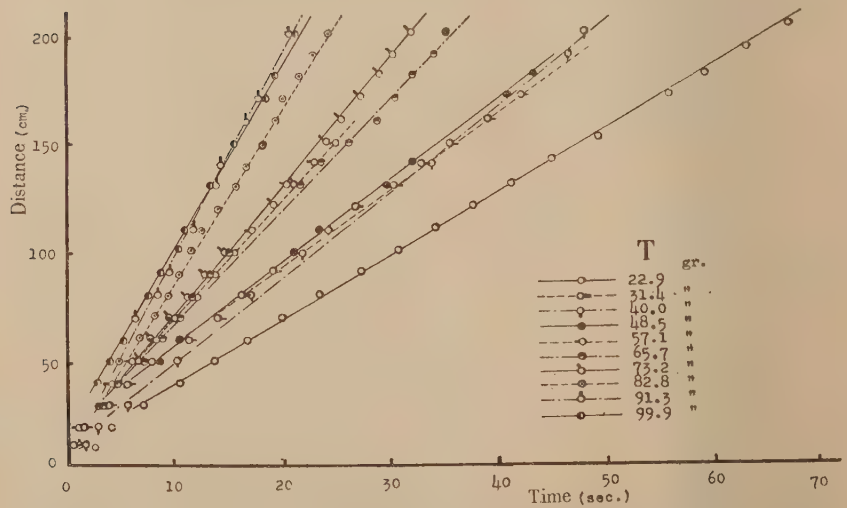


Fig. 2. The time when the lead line moved some distance under the action of weight of $T$ g.

And in that case, the relation between the weight $T$ in g-wt and the constant speed $V$ in cm/sec can be formulated by $T=11\,V.^{99}$

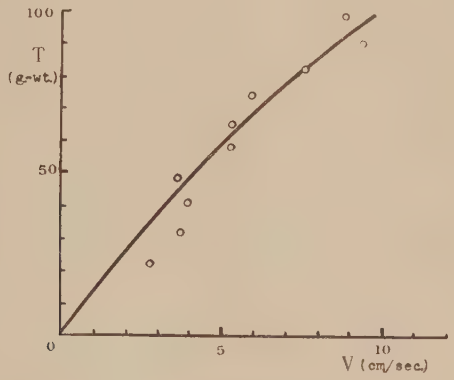


Fig. 3. Constant speed of net $V$, under the action of weight $T$.

Table 2. Constant speed under the action of various weights.

| Weight (g) | 22.9 | 31.4 | 40.0 | 48.5 | 57.1 | 65.7 | 73.2 | 82.8 | 91.3 | 99.9 |
|---|---|---|---|---|---|---|---|---|---|---|
| Speed (cm/sec) | 2.73 | 3.63 | 3.85 | 3.52 | 5.10 | 5.18 | 5.74 | 7.57 | 9.38 | 8.78 |

Fig. 4 and table 3 show the depth of lead line when it moved various distance under the action and various weights, and fig. 5 shows the final value of the depth against the initial one.

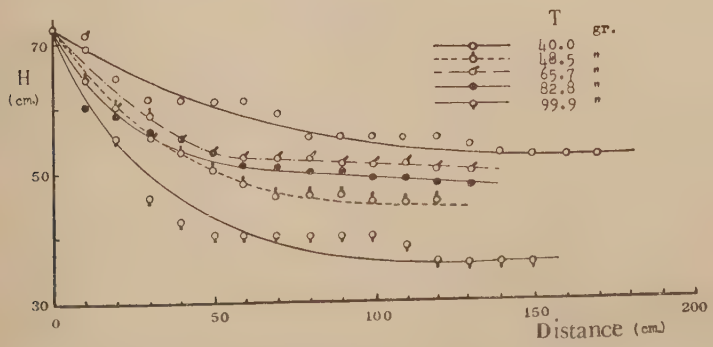


Fig. 4. Depth of lead line $H$ when it moved various distance under the action of weight $T$.

From fig. 5, we know that the stronger the leadline is pulled the more it goes up.

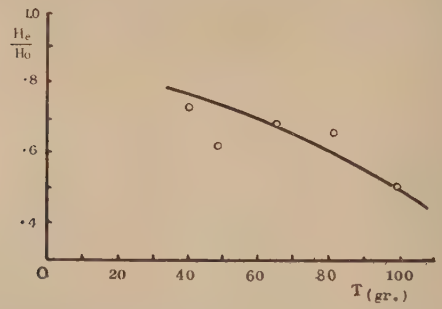


Fig. 5. Final value of the depth of lead line, $H_e$ against its initial one, $H_0$ under the action of weight $T$.

Table 3. Depth of the lead line when it moved various distance under the action of various weights.

| Distance (cm) / Weight (g) | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | 110 | 120 | 130 | 140 | 150 | 160 | 170 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 40.0 | 72 | 68 | 64 | 61 | 61 | 61 | 61 | 58 | 55 | 55 | 55 | 55 | 55 | 54 | 53 | 53 | 53 | 53 |
| 48.5 | 72 | 64 | 60 | 58 | 53 | 50 | 48 | 46 | 46 | 46 | 45 | 45 | 45 | | | | | |
| 65.7 | 72 | 71 | 60 | 55 | 54 | 53 | 52 | 52 | 52 | 51 | 51 | 51 | 50 | 50 | 50 | | | |
| 82.8 | 72 | 60 | 58 | 56 | 55 | 51 | 51 | 51 | 50 | 50 | 49 | 49 | 48 | 48 | 48 | | | |
| 99.9 | 72 | 60 | 54 | 46 | 42 | 40 | 40 | 40 | 40 | 40 | 40 | 38 | 36 | 36 | 36 | 36 | | |

In conclusion, we wish to express our best thanks to Prof. M. TAUTI and Assistant Prof. K. MIYOSI for their advices given during the course of the experiment.

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# ON THE EFFICACY OF NET PRESERVATIVES PART II. EFFECT OF PENTACHLOROPHENOL

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Takeaki Kikuchi and Yoshio Imai

(Received May 20, 1954)

In a recent paper[1] the authors reported the efficacy of some aromatic chlorine derivatives for fish-net preservatives by an experimental exposure in sea water. Above all sodium pentachlorophenate was a good preservative, namely when sodium pentachlorophenate followed by a treatment with $CuSO_4$ was almost like cutch (with $K_2Cr_2O_7$. $CuSO_4$) treated. This method, which deposits a comparatively insoluble form of cupper pentachlorophenate in the lines, appeared to be appliciable for fish-net preservative.

Accordingly, since in 1952, following series of exposures and tests were carried out, and present paper are involved them.

(a) Effect of sodium pentachlorophenate in different concentration.
(b) Effect of sodium pentachlorophenate followed by a treatment with cutch.
(c) Effect of pentachlorophenol followed by a treatment with a proprietary waterploofing Isocyanate.

In these studies following two series of experiments were undertaken with a view of determining the effect of preservatives.

(a) Series exposed in sea water at Tateyama.
(b) Series exposed to weather condition at Kurihama.

## EXPERIMENTS

Notation of sample

In the following key all samples designated by the same letter of the Alphabet are always treated with the same preservatives in the same way. In all results recorded here in to the symbol and identification under refer to this key.

Key to symbol for preservatives studied

A .....White line—untreated—cotton line 20′S 3/15—used as a control.

B .....Cutch ($K_2Cr_2O_7$. $CuSO_4$)—Two per cent conc. in water. Lines were dipped into this solution and allowed to become through saturated. This required 30 minutes at boiling point. Then the lines were treated with 1% $K_2Cr_2O_7$ and 3% $CuSO_4$ mixture solution for 30 minutes at 80°C and immediatly washed in water and spread to dry (not piled in a heap).—used as a comparison.

C .....Coal tar—The lines were soaked in heavy tar (not dilute with creosote) at 80°C for 30 minutes. As the lines were drawn out of the tar they

were drawn between the fingers in order to remove the excess tar adheling to the lines—used as a comparison.

D .....Na.P.C.P. 2%—Two per cent sodium pentachlorophenate conc. in water. Lines were dipped into this solution and allowed to become through saturated. This required 45 minutes at boiling point.

E .....Na.P.C.P. 5%—Five per cent sodium pentachlorophenate conc. in water was used. Treated as D.

F .....Na.P.C.P. 2%+$CuSO_4$—The first treatment was the same as D, and second treated in 3% $CuSO_4$ solution was used, 30 minutes at 80°C. By this treatment sodium pentachlorophenate was converted in a insoluble form and fixed on net cord.

G.....Na.P.C.P. 5%+$CuSO_4$—The first treatment was the same as E, and second was the same as F.

H.....Na.P.C.P. 2%+cutch 2%—The first treatment was the same as D, and the second 2% cutch solution in water was used. Second treatment was the same as the first treatment of cutch 2% B.

I.....Na.P.C.P. 2%+cutch 2% ($K_2Cr_2O_7$. $CuSO_4$)—The first and second treatment was the same as H, and in the third treatment 1% $K_2Cr_2O_7$ and 3% $CuSO_4$ solution was used, at 80°C for 30 minutes.

J.....P.C.P. 5% benzol solution—Pentachlorophenol 5% conc. in benzol. Lines were dipped into this solution and allowed to become through saturated. It requires 45 minutes at boiling point. In this treatment reflex cooler was used.

K.....Isocyanate—Octadecyl isocyanate 5%, and diphenyl methan diisocyanate 5% conc. in benzol. In this case reflex cooler was used too.

L .....P.C.P. 5%+Isocyanate—The first treatment was the same as J, and the second was the same as K.

Increase in weight caused by application of preservatives.

Table 1. Increase in weight of cotton lines caused by preservatives.

| Symbol and treatment | Comparative weight |
|---|---|
| A-White line, untreated | 100.0% |
| B-Cutch 2% ($K_2Cr_2O_7$. $CuSO_4$) | 108.5 |
| C-Coal tar | — |
| D-Na.P.C.P.* 2% | 100.6 |
| E-Na.P.C.P. 5% | 103.5 |
| F-Na.P.C.P. 2% $CuSO_4$ | 103.8 |
| G-Na.P.C.P. 5%+$CuSO_4$ | 106.9 |
| H-Na.P.C.P. 2%+Cutch 2% | 106.2 |
| I-Na.P.C.P. 2%+Cutch 2%+$CuSO_4 \cdot K_2Cr_2O_7$ | 109.3 |
| J-P.C.P. 5% | 102.3 |
| K-Isocyanate | 114.6 |
| L-P.C.P. 5%+Isocyanate | 115.6 |

* Na.P.C.P.=Sodium pentachlorophenate.

Among the properties of textile that make them suitable for fishing is lightness. A light net is more easily and more rapidly handled than heavy one, and consequently less labor is required.

It is therefore important to determine the increase in weight caused by

preservation and to select the preservatives that impart least weight to the nets, other conditions being the same. In the experiment so far describes in this paper this factor was determined by weighing the sample lines before and after treatment. Table 1. give the results of the determination of increase in weight of cotton lines caused by the preservatives. These results were weighed in the air-dry condition.

**A. Series exposed in sea water at Tateyama**

(1) Material and Method.

Cotton lines (20′S 3/15) were treated by each of two preservatives, namely sodium pentachlorophenate in six different treatment D, E, F, G, H, and I; and pentachlorophenol in three different treatment J, K, and L; untreated white line A was used as a control, and cutch B, and coal tar C, were used as comparison.

Ten samples were prepared by each preservatives, one to hold as an unexposed check; the other nine to be exposed.

These samples were fastened to an iron frame and put in sea water at Tateyama Bay (Chiba prefecture) from July 1 to Sept. 28, 1952.

At every ten days one sample treated by each preservative and three control samples were removed and observed marine growth on the lines and then tested tensile strength, in wet condition.

(2) Water condition at Tateyama.

The temperature and density of water during the period the lines were exposed are shown in Table 2. There were abundant growth of barnacless Bryozoa, and other attached marine growths.

Table 2. Water condition at Tateyama, 1952.

| Period | Water temperature | Density |
|---|---|---|
| July 1—July 10 | 22.0°C | 24.06 |
| July 11—July 20 | 23.0 | 25.03 |
| July 21—July 30 | 24.9 | 24.55 |
| July 31—Aug. 9 | 24.9 | 24.87 |
| Aug. 10—Aug. 19 | 26.6 | 25.20 |
| Aug. 20—Aug. 29 | 26.5 | 24.97 |
| Aug. 30—Sept. 8 | 26.1 | 25.37 |
| Sept. 9—Sept. 18 | 25.4 | 24.93 |
| Sept. 19—Sept. 28 | 24.3 | 25.06 |

(3) Tensile strength and effective day.

Because of variation in the line it is necessary to take the average of a number of tests. The figure given for the control is the average of 20 tests, all others of 10. Table 3 gives the results of the measurements of tensile strength for the lines exposed in sea water at Tateyama. The same results were expressed graphically in Figures 1 and 2.

Effective day calculated by M. Tauchi's equation[2] are shown in Table 5. The equation and calculate method was already described in part I.[1]

Table 3. Tensile strength of cotton lines exposed in sea water at Tateyama, 1952.

| Symbol and treatment | Unexposed | Number of days exposed | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 |
| | Tensile strength in Kg. | | | | | | | | | |
| A-White line, untreated, control | 9.76[1] | 9.06 | 6.73 | 6.40 | 5.85 | 3.60 | 2.00 | 0 | — | — |
| B-Cutch 2% ($K_2Cr_2O_7$. $CuSO_4$) | 9.98 | 11.00 | 9.92 | 9.34 | 8.22 | 6.86 | 5.02 | 4.26 | 3.26 | 1.70 |
| C-Coal tar, control | 6.04 | 6.56 | 6.50 | 5.82 | 5.30 | 4.78 | 4.44 | 5.26 | 4.80 | 4.38 |
| D-Na.P.C.P. 2% | 9.92 | 8.66 | 8.48 | 6.77 | 4.96 | 3.14 | 0 | — | — | — |
| E-Na.P.C.P. 5% | 9.82 | —[2] | 5.34 | 3.54 | 3.56 | 3.30 | 0 | — | — | — |
| F-Na.P.C.P. 2% + $CuSO_4$ | 9.46 | —[2] | 9.34 | 6.70 | 6.16 | 4.08 | 2.73 | 1.07 | 0 | — |
| G-Na.P.C.P. 5% + $CuSO_4$ | 9.72 | —[2] | 9.36 | 7.48 | 7.92 | 5.66 | 3.20 | 3.31 | 0 | — |
| H-Na.P.C.P. 2% + Cutch 2% | 9.00 | —[2] | 8.56 | 5.44 | 5.04 | 3.06 | 1.70 | 2.70 | 1.84 | 0 |
| I-Na.P.C. 2% + Cutch 2% + $K_2Cr_2O_7$. $CuSO_4$ | 9.20 | 9.44 | 9.42 | 8.74 | 6.50 | 6.70 | 5.20 | 3.80 | 3.72 | 2.65 |
| J-P.C.P. 5% | 10.77 | 8.32 | 8.44 | 5.16 | 4.60 | 3.20 | 0 | — | — | — |
| K-Isocyanate | 10.04 | 9.12 | 8.56 | 5.76 | 4.52 | 1.10 | 0 | — | — | — |
| L-P.C.P. 5% + Isocyanate | 9.44 | 8.50 | 8.04 | 5.38 | 5.28 | 4.78 | 2.47 | 0 | — | — |

[1] Average of 20 breaks; every other figure in this table is the average of 10 breaks.
[2] No sample run.

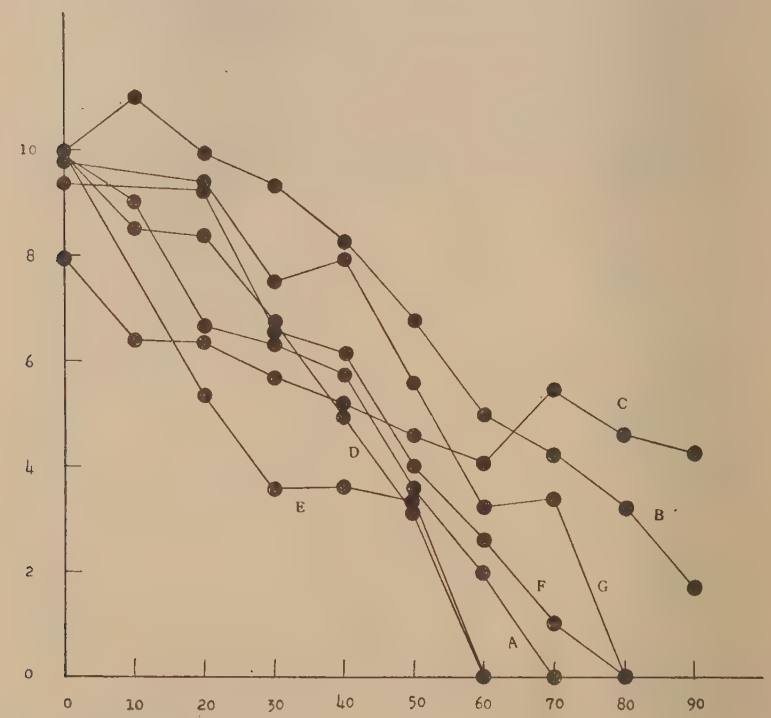


Fig. 1. Tensile strength of cotton line exposed in sea water at Tateyama, 1952. Ordinate....tensile strength. (Kg.); Abscissa....days exposed.

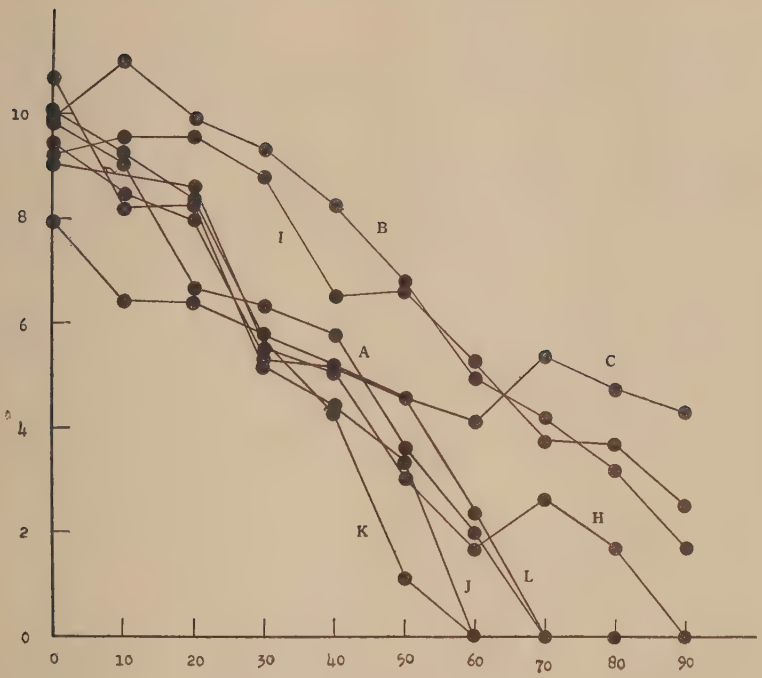


Fig. 2. Tensile strength of cotton line exposed in sea water at Tateyama, 1952. Ordinate....tensile strength. (Kg.); Abscissa....days exposed.

Table 4. Effective days of cotton lines exposed in sea water at Tateyama, 1952.

| Symbol and treatment | $t_0$ | $t_e$ | $k \times 10^2$ |
|---|---|---|---|
| A-White line, untreated, control | 10 | 43 | 2.5 |
| B-Cutch 2% ($K_2Cr_2O_7$. $CuSO_4$), control | 10 | 60 | 2.2 |
| C-Coal tar, control | — | — | — |
| D-Na.P.C.P. 2% | 0 | 38 | 3.1 |
| E-Na.P.C.P. 5% | — | — | — |
| F-Na.P.C.P. 2%+$CuSO_4$ | 20 | 46 | 3.3 |
| G-Na.P.C.P. 5%+$CuSO_4$ | 20 | 56 | 2.7 |
| H-Na.P.C.P. 2%+Cutch 2% | 20 | 46 | 1.7 |
| I-Na.P.C.P. 2%+Cutch 2%+$K_2Cr_2O_7$. $CuSO_4$ | 20 | 63 | 2.4 |
| J-P.C.P. 5% | 0 | 33 | 3.7 |
| K-Isocyanate | 0 | 35 | 4.6 |
| L-P.C.P. 5%+Isocyanate | 0 | 45 | 2.6 |

$t_0$=Days that the line is maintained for its original tensile strength.
$t_e$=Effective days of preservation.
$\kappa$=Weaken coefficient.

(4) Results.

(a) Effect of sodium pentachlorophenate due to the different concentration. Sodium pentachlorophenate treated alone D, and E were poor results, it was the

same as shown in our recent paper (part I) as treated alone. These two were showed no superiority to untreated line.

Sodium pentachlorophenate followed by a treatment with $CuSO_4$ F and G was superior to those were treated sodium pentachlorophenate alone D and E. It was seemed that the fixthing method in insoluble form of copper pentachlorophenate, was effective.

Especially 5% G, was good enough, almost equal to cutch (with $K_2Cr_2O_7$. $CuSO_4$) treated as B. Its effective days was 56 days (cutch B was 60 days) and weaken coefficient was 0.027 (cutch was 0.022), 2% F ; was not so good as 5%, G ; its effective days was 46 days, therefore it was superior to untreated A, only a little.

(b) Effect of sodium pentachlorophenate followed by a treatment with cutch. Sodium pentachlorophenate followed by a treatment with cutch H was better than sodium pentachlorophenate alone, D, but it was less superior to cutch (with $K_2Cr_2O_7$. $CuSO_4$), treated B.

Sodium pentachlorophenate followed by a treatment with cutch ($K_2Cr_2O_7$. $CuSO_4$), I ; was excellent. Its effective days was 63 days and weaken coefficient was 0.024.

It was more superior to all other B, D, E, F, G, H.

(c) Effect of pentachlorophenol followed by a treatment with waterproofing material Isocyanate.

This experiment was undertaken with the object in view to give the preservation and waterproof property to cotton lines. But this trial was not effective.

Pentachlorophenol and Isocyanate treated alone J, and K, showed no superiority to untreated line, and pentachlorophenol followed by a treatment with Isocyanate, L ; showed only little superiority to untreated line. Its effective days was 45 days and untreated line used as a control was 43 days.

(5) Resistance to fouling by marine growth.

Present paper given an observation of the lines conditions after fifty days as follows:—

The condition of lines after fifty days exposed in sea water at Tateyama.

| Symbol and treatment | Condition after fifty days in water |
|---|---|
| A—White line ; untreated | Slightly fouled some algae ; no barnacles ; a few Bugula nelitina Linné |
| B—Cutch 2% ($K_2Cr_2O_7$. $CuSO_4$) | Slightly fouled some algae ; no barnacles |
| C—Coal tar | Covered with many of barnacles, and a few Bugula meritina Linné |
| D—Na.P.C.P. 2% | Few algae and barnacles ; nearly clean |
| E—Na.P.C.P. 5% | Do. |
| F—Na.P.C.P. 2%+$CuSO_4$ | Substantially clean |
| G—Na.P.C.P. 5%+$CuSO_4$ | Do. |
| H—Na.P.C.P. 2%+Cutch 2% | Few algae and barnacles ; nearly clean |
| I—Na.P.C.P. 2%+Cutch 2%+ $K_2Cr_2O_7$. $CuSO_7$ | Do. |
| J—P.C.P. 5% | Few algae and barnacles ; and a few Bugula Neritina Linné |
| K—Isocyanate | Substantially clean |
| L—P.C.P. 5%+Isocyanate | Slightly fouled ; some algae and barnacles |

**B. Series exposed to weather condition at Kurihama**

(1) Material and method.

Cotton lines (20′S 3/15) were prepared by each of four different preservatives and preservative method, namely sodium-pentachlorophenate in two different combinations G, and GC ; a proprietary water proofing material Isocyanate K, pentachlorophenol and Isocyanate combination L, untreated white line A, was used as a control, and cutch B, coal tar C, were used as comparison.

Seven samples were prepared by each preservatives, one to hold as an unexposed check ; the other six to be exposed.

These samples were lightly streched on the roof of the Tokyo University of Fisheries, Kurihama, from Sept. 6, 1952 to March 4, 1953. At the end of succeeding month for six month one sample treated by each preservative, one control and two comparison were removed and tested for tensile strength. These tests of lines were always carried out in wet condition.

(2) Weather condition at Kurihama.

The temperature, humidity, cloud and total sun hours during this experiment were shown in Table 5.

The temperature, humidity, and cloud is the average of 30 days.

Table 5. Weather condition at Kurihama, 1952-53.

| Period | Temperature | Humidity | Cloud | Sun hours |
|---|---|---|---|---|
| Sept. 6—Oct. 5 | 22.9°C | 83.5 | 8.0 | 125.0 |
| Oct. 6—Nov. 4 | 17.1 | 78.2 | 6.9 | 124.2 |
| Nov. 5—Dec. 4 | 12.3 | 77.4 | 6.6 | 104.8 |
| Dec. 5—Jan. 3 | 6.2 | 70.0 | 4.7 | 152.1 |
| Jan. 4—Feb. 2 | 3.8 | 58.0 | 3.9 | 186.0 |
| Feb. 3—Mar. 4 | 5.3 | 63.3 | 5.5 | 156.1 |

(3) Tensile strength.

Because of variation in the lines it is necessary to take the average of number of tests. The figure given for the control is the average of 20, all others of 10.

Table 6, gives the results of the measurements of tensile strength for the lines exposed to weather condition at Kurihama. The results of tensile strength are expressed graphically in Fig. 3.

(4) Results.

In the present instance the lines treated with sodium pentachlorophenate, G and GC on exposure to the weather suffer a gradual though small diminution of strength. At the end of six months' exposure to weather the lines were still strong enough to use.

The other preservatives Isocyanate K, Isocyanate+pentachlorophenol L, suffer a comparatively rapid diminution of strength during the exposure to weather.

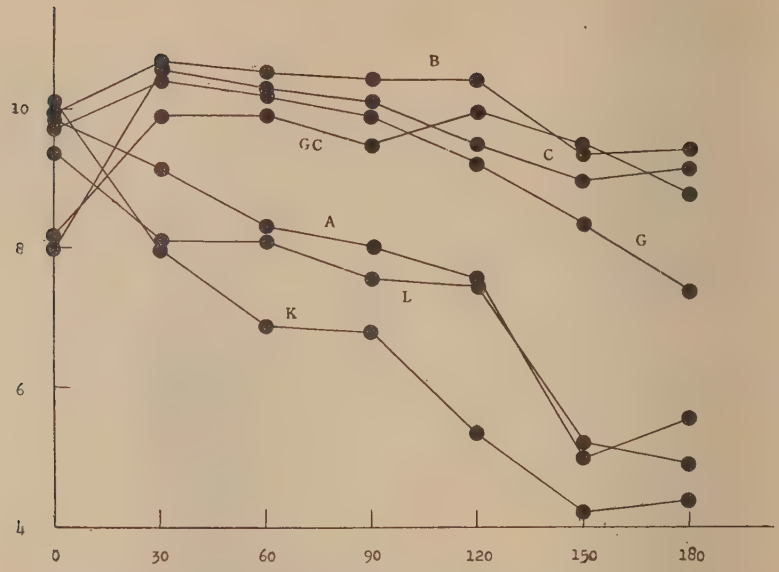


Fig. 3. Tensile strength of cotton line exposed to weather condition at Kurihama, 1952-53. Ordinate....tensile strength. (Kg.); Abscissa....days exposed.

Table 6. Tensile strength of cotton lines exposed to weather condition at Kurihama, 1952-1953.

| Symbol and treatment | Unexposed | Days exposed | | | | | |
|---|---|---|---|---|---|---|---|
| | | 30 | 60 | 90 | 120 | 150 | 180 |
| | | Tensile strength in Kg. | | | | | |
| A—White line, untreated, control | 9.76[1] | 9.44 | 8.26 | 8.02 | 7.56 | 5.04 | 5.52 |
| B—Cutch 2% ($K_2Cr_2O_7$. $CuSO_4$), control | 9.98 | 10.68 | 10.50 | 10.46 | 10.44 | 9.34 | 9.40 |
| C—Coal tar, control | 8.04 | 10.52 | 10.30 | 10.10 | 9.50 | 9.04 | 9.20 |
| G—Na.P.C.P. 5%+$CuSO_4$ | 9.72 | 10.52 | 10.24 | 9.84 | 9.34 | 8.38 | 7.48 |
| K—Isocyanate | 10.04 | 8.02 | 6.90 | 6.79 | 5.40 | 4.24 | 4.40 |
| L—P.C.P.+Isocyanate | 9.44 | 8.02 | 8.06 | 7.56 | 7.54 | 5.12 | 4.96 |
| GC-(G)+Coal tar | 8.17 | 9.82 | 9.82 | 9.50 | 10.00 | 9.40 | 8.78 |

[1] Average of 20 breaks, every others are 10.

## SUMMARY

The principal results and conclusions arrived at and report in detail in the main part of this paper are here summarized.

(1) The following preservations and preservative method were tested; sodium pentachlorophenate in different concentration. Sodium pentachlorophenate followed by a treatment with cutch, and pentachlorophenol followed by a treatment with

a proprietary waterproofing material Isocyanate.
(2) The textile tested were cotton line (20′S 3/15).
(3) Series of lines treated with various preservatives were exposed in sea water at Tateyama (Chiba prefecture) from July 1 to Sept. 28, 1952, and exposed to weather condition at Kurihama from Sept. 6, 1952 to Mar. 4, 1953.
(4) Sodium pentachlorophenol was a poor preservative. Line treated alone showed no superiority to untreated line.
(5) Sodium pentachlorophenate followed by a treatment with $CuSO_4$ was a good preservatives, as it was a recent paper (Part I). In this case, sodium pentachlorophenate 5%+$CuSO_4$ was more effective than others.
(6) Sodium pentachlorophenate followed by a treatment with cutch showed no superiority to compared with cutch ($K_2Cr_2O_7$. $CuSO_4$) treated. And sodium pentachlorophenate followed by a treatment with cutch ($K_2Cr_2O_7$. $CuSO_4$) showed little superiority to cutch ($K_2Cr_2O_7$. $CuSO_4$).
(7) Isocyanate and pentachlorophenol used alone, showed no favorable effect. Line treated by these preservatives showed no superiority to untreated line.
(8) Pentachlorophenol+Isocyanate treated line showed little superiority to untreated line.
(9) In the series of exposure to weather condition at Kurihama, from Sept. 6, 1952 to Mar. 4, 1953, the lines treated with sodium pentachlorophenate+$CuSO_4$, and sodium pentachlorophenate+$CuSO_4$+Coal tar, suffer a gradual though small diminution of strength, Isocyanate and Isocyanate+pentachlorophenol suffer a comparative rapid diminution of strength.

Finally, the authors express their hearty thanks to Mr. M. Inoue, who has assisted this work, and wish to express their thanks to the Ministry of Education by which the present investigation has undergone the financial aid.

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# ON THE EFFICACY OF NET PRESERVATIVES PART III. ATMOSPHERIC EXPOSURE OF COTTON LINE FOULED BY FISH OIL, FATTY ACID AND FISH RESIDUE

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The fished nets fouled by fish oil, fish slime and other substances appear to diminish their strength during the exposure to weather condition or long storage. Many papers reported to the decrease of strength for amillan, vinylon, cotton, etc., fouled by fish oil e.g. cod liver oil and shark liver oil, during the experimental storage in high humidity. They did not however identify the deterioration responsible for the weather condition.

Accordingly, in 1953–1954, a small preliminary series of weather exposures and tests were carried out that included four treatment-whale oil, oleic acid, palmitic acid and fish residue.

## EXPERIMENTAL

1. Material and method.

Cotton lines (20′S 3/15) were prepared by each of four different substances, namely whale oil D, fish residue E, palmitic acid F, and oleic acid G; untreated white line A was used as a control, and cutch ($K_2Cr_2O_7 \cdot CuSO_4$) B, coal tar C-were used as comparison.

Seven samples were prepared by each substance, one to hold as an unexposed check; the other six to be exposed.

These samples were lightly streched on the roof of the Tokyo University of Fisheries, Kurihama, from Oct. 3, 1953 to Mar. 1, 1954. At the end of succeeding month for five months one sample treated by each preservative, one control and two comparison were removed and test for tensile strength. These tests were always carried out in wet condition of lines.

2. Symbol and treatment.

A...White line—untreated—cotton line 20′S 3/15—used as a control.

B...Cutch ($K_2Cr_2O_7 \cdot CuSO_4$)—2% conc. in water. Lines were dipped into this solution and allowed to become saturated. This required 30 minutes at boiling point. Then the lines were treated with 1% $K_2Cr_2O_7$ and 3% $CuSO_4$ mixture solution for 30 minutes at 80°C and immediatly washed in water.—used as a comparison.

C...Coal tar—The lines were soaked into heavy tar (not diluted with creosote) for 30 minutes at 80°C. As the lines were drawn out of the tar they were drawn between the fingers in order to remove the excess tar adheling to the

lines—used as a comparison.

D...Whale oil—The lines were dipped into whale oil for one hour. To remove the excess oil adhering to the lines, treared as coal tar C.

The properties of this whale oil were; Acid value=1.10, Iodine value=118.0 and Peroxide value=1.30.

E...Fish residue—The lines were mixed with the fish residue, involved fish blood, slime and others, for about one hour. So it was preliminary application that did not considered to the adhering quantity of fish residue. The properties of fish (Mackerel Pike) were; moisture=75.4%, crude fat=12.50%, crude protein=4.05%.

F...Palmitic acid—The lines were treated in saturated palmitic acid in petroleum-ether for one hour. Melting point of this palmitic acid was 62.0°C.

G...Oleic acid—The lines were treated in oleic acid for one hour. As the lines drawn out of the oleic acid they were drawn between the fingers in order to remove the excess oleic acid adhering to the lines.

The properties of oleic acid were; Iodine value=72.3, Neutral value=231.5. It seemed to suffer a slight oxidation.

3. Weather condition at Kurihama.

The temperature, humidity, cloud and total sun hours during the period the lines were exposed are shown in Table 1. The temperature, humidity and cloud are the average of 30 days.

Table 1. Weather condition at Kurihama, 1953-1954.

| Period | Temperature | Humidity | Cloud | Sun-hour |
|---|---|---|---|---|
| Oct. 3—Nov. 1 | 16.8°C | 78.5 | 6.6 | 158.8 |
| Nov. 2—Dec. 1 | 10.7 | 64.0 | 5.4 | 156.4 |
| Dec. 2—Dec. 31 | 8.0 | 68.4 | 5.6 | 121.7 |
| Jan. 1—Jan. 30 | 4.8 | 66.0 | 5.8 | 114.7 |
| Jan. 31—Mar. 1 | 5.9 | 63.5 | 4.8 | 176.5 |

4. Tensile strength.

Because of variation in the line it is necessary to take the average of a number of tests. The figure given for the control is the average of 30 tests, all others of 10. Table 2. gives the results of the measurements of tensile strength for the lines exposed to weather condition at Kurihama. The same results were expressed graphically in Figure 1.

Here, it will be observed, the lines treated by any of the materials suffer an immediate diminution of strength even before they are exposed. The diminution of strength after freshly treated for untreated were; coal tar C, 14%; whale oil D, 28%; fish residue E, 30% respectively, and palmitic acid F and oleic acid G were almost invariable.

The lines treated with whale oil D, on exposed to the weather suffer a very rapid diminution of tensile strength. At the end of 30 days exposure to weather, D was almost rotten and not useful. Its tensile strength of after 30 days was 1.85 Kg, and loss rate was about 88%.

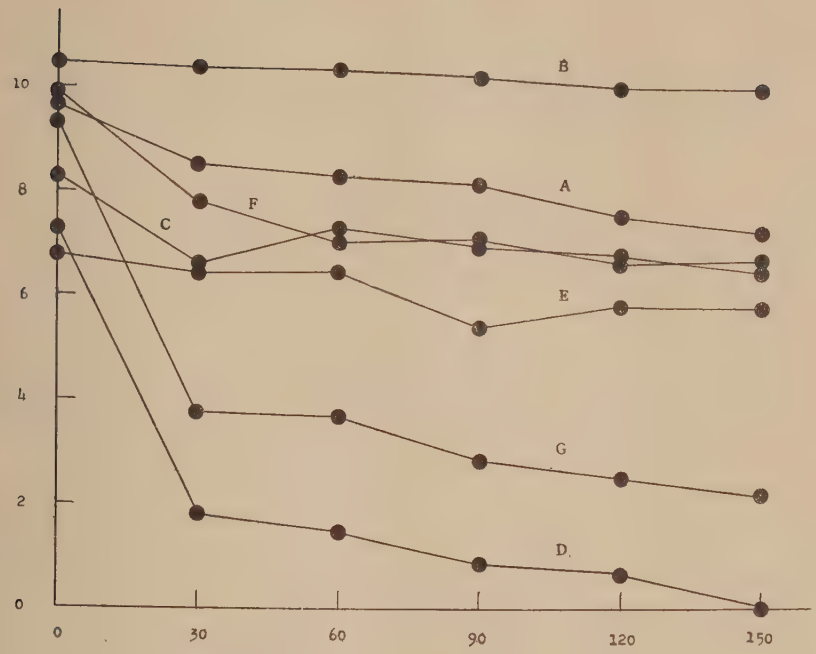


Fig. 1. Tensile strength of cotton line exposed to weather condition at Kurihama, 1953–54.

Ordinate...tensile strength. (Kg.); Abscissa...days exposed.

Table 2. Tensile strength of cotton lines exposed in weather condition at Kurihama, 1953–54.

| Symbol and treatment | Unexposed | Days exposed | | | | |
|---|---|---|---|---|---|---|
| | | 30 | 60 | 90 | 120 | 150 |
| | | Tensile strength in Kg. | | | | |
| A–White line, untreated, control | 9.72[4] | 8.36 | 8.30 | 8.10 | 7.54 | 7.10 |
| B–Cutch 2% ($K_2Cr_2O_7 \cdot CuSO_4$), control | 10.52 | 10.48 | 10.18 | 10.18 | 10.02 | 10.05 |
| C–Coal tar, control | 8.36 | 6.66 | 7.12 | 6.86 | 6.76 | 6.56 |
| D–Oil (whale)[1] | 7.20 | 1.85 | 1.40 | 0.90 | 0.70 | 0 |
| E–Fish residure | 6.80 | 6.60 | 6.56 | 5.41 | 5.87 | 5.86 |
| F–Palmitic acid[2] | 9.90 | 7.70 | 7.00 | 6.90 | 6.78 | 6.92 |
| G–Oleic acid[3] | 9.36 | 3.76 | 3.70 | 2.96 | 2.38 | 2.10 |

1)...Whale oil: Acid value=11.0, Iodine value=118.0, Peroxide value=1.30.
2)...Palmitic acid, melting point=62.0°C.
3)...Oleic acid: Iodine value=72.3, Neutral value=231.5.
4)...Average of 30 breaks; every other figure in this table is the average of 10 breaks.

Fish residue E, showed a rapid diminution of strength after freshly treated, but gradual diminution to weather condition for 150 days. Its strength of after 150 days was 5.86 Kg, and loss rate was about 14%.

Palmitic acid F, on exposure to weather suffer a gradual though small diminution of strength. At the end of 150 days exposure to weather, its tensile strength was 6.92 Kg, and loss rate was about 30%.

Oleic acid G, on exposure to weather suffer a rapid diminution of tensile strength. At the end of 30 days its strength was 3.76 Kg and loss rate was about 60%, and after 150 days 2.10 Kg and 78%, respectively.

## SUMMARY

The principal results and conclusions arrived at and report in detail in the main part of this paper are here summarized.

(1) The following treatment of four substances were tested; whale oil, oleic acid, palmitic acid and fish residue.

(2) The textile tested were cotton line (20′S 3/15).

(3) Series of lines treated with four substances were exposed to weather condition at Kurihama (Kanagawa prefecture) from Oct. 3, 1953 to Mar. 1, 1954.

(4) The diminution of strength after freshly treatment was in order of; fish residue, whale oil, oleic acid, palmitic acid.

(5) All samples shown more or less diminution of strength during the 150 days exposure to weather condition. And the loss rate of strength was; in order of whale oil, oleic acid, palmitic acid, fish residue.

Finally, the authors wish to express their thanks to the Ministry of Education by which the present investigation has undergone the financial aid.

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# NOTE ON THE THERMAL DECOMPOSITION OF UREA IN THE MUSCLE OF SHARK-FISH.

Michizo Suyama and Tadashi Tokuhiro

(Received May 15, 1954)

In our previous work[1)2)], calculating the strength of urea at various parts of the body of cartilaginous fish, we have been led to a suggestive conclusion as to the physiological significance of this substance, while, though not explicitly mentioned, we paid special attention in that case in estimating the moisture content of the samples, in reference to which the urea strengths were calculated, for the reason now to be described in this paper.

Namely, it was found upon heating the sample as usual to obtain its dry matter that the weight of dry matter invariably continued to decrease gradually for any length of time. For example, while the minced and brayed muscle of *Prionace glauca* (L.) [pH 8.7, volatile base N 395.8 mg. %] was submitted to drying at 105±1.5°C. under condition of ordinary pressure for 1 to 7 hours, its dry matter decreased as shown in Fig. 1.

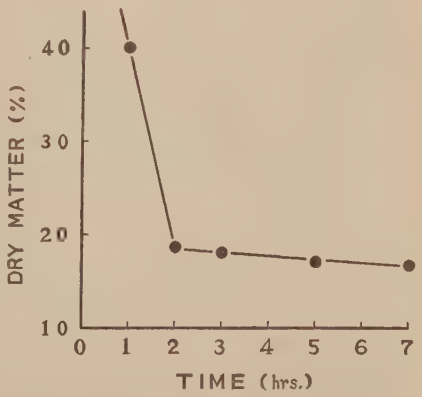


Fig. 1. Weight change of muscle paste of *Prionace glauca* (L.) during heat-desiccation.

From this, we can see the indication that the water of the muscle was eliminated almost completely during first 2 hours, but the sample continues further decrease in weight. This slight decrease seems, from the form of the curve, to be not due to the difficulty of desiccation by the abovementioned heating, but to the formation of some volatile substances through prolonged heating. So the authors paid attention to urea, a substance popular in shark-fish muscle and rather liable to thermal decomposition, and persued its decomposition on heating.

## Experimental and Results

**Exp. 1.** *The effect of heating-temperature on the urea content:* Fresh muscle of *Prionace glauca* (L.) [pH. 6.7, volatile base N 46.12 mg. %] was minced, spread into thin films in a number of large weighing tubes, and dried for 2 hours at 100°C. Every one of these films was then heated additionally for 1 hour but respectively at different temperatures between 100~135°C. The urea was extracted with a dilute solution of trichloracetic acid from dried sample, and

analysed by xanthydrol method. The result obtained is illustrated in Fig. 2.

It is obvious from Fig. 2 that the content of urea decreases on heating the more markedly at the higher temperature. Though, as well known, urea melts at 132°C. accompanying decomposition, it decomposition can truly take place even at temperatures lower than the melting point. The simultaneous decrease in dry matter occurring at temperatures above 100°C. seems as if it were interpretable exclusively by the decrease in urea content, because the results of substracting the amount of decomposed urea determined at several temperatures from the amount of dry matter reached after 2 hours heating at 100°C. fall closely upon the curve giving the dry matter above 100°C. However, this apparent excellent agreement proved as will be shown later to be but of accident.

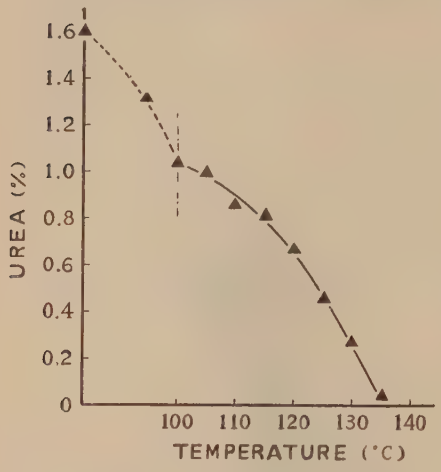


Fig. 2. The effect of temperature on the urea content of fresh *Prionace glauca* (L.) muscle dried at successively higher temperatures.

For the sake of comparison, a not-very-fresh sample of muscle of *Prionace glauca* (L.) [pH 8.7, volatile base N 395.8 mg. %], having previously been kept for 16 hours in an incubator at 30°C., was treated in the same way as above, leading to the result as shown in Fig. 3.

The decrease in the content of urea during heat treatment also seem deserving to be remarked.

It may be said from this experiment that the decomposition of urea in muscle of shark-fish does proceed even at about 100°C. suggesting appreciable thermal ability of this substance. Thus, when the muscle of *Carcharinus melanopterus* (Q. & G.) [pH 6.7, volatile basic N 33.9 mg. %] is dried for 1 hour at 60~100°C., its decomposition seems

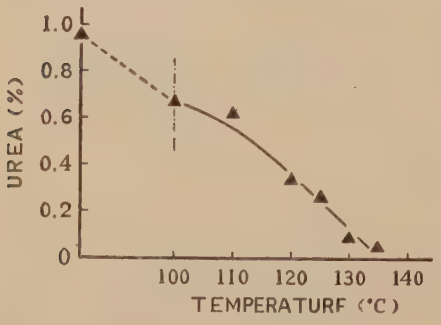


Fig. 3. The effect of temperature on the urea content of not-fresh *Prionace glauca* (L.) muscle at successively higer temperatures.

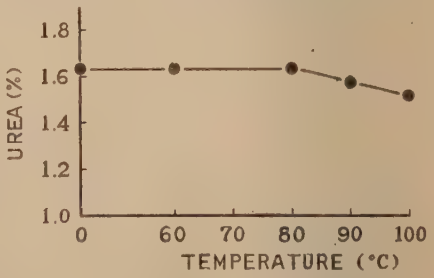


Fig. 4. The effect of temperature on the decomposition of urea.

to commence already at a temperature as low as 80°C. as illustrated in Fig. 4.

**Exp. 2.** Now it is known, on the other hand, that pure urea decomposes readily upon heating to melt, yielding biuret, cyanuric acid, and ammonia. Therefore, if the urea existing in shark-fish muscle is decomposed by heat just in the same manner as pure urea, it is clear that the thermal decomposition should not quantitatively represent the weight loss in the sample of muscle, for biuret and cyanuric acid are to remain as non-volatile matter. However, urea is said to be a substance of marked reactivity; so, in the case of a heat-dried sample of shark-fish muscle, it is rather very likely that a significant portion of urea interacts with some compounds inherent to the muscular system without yielding those substances such as biuret, cyanuric acid, and ammonia, which are usually attainable with pure urea.

Hereupon the authors investigated this time the modification brought to the thermal decomposition of urea by co-existent meat substances.

Chopped muscle of bonito-fish was devided into two groups, each weighing 70 gm. To one of these groups were added 7 ml. of a urea solution, corresponding to about 1.2 gm. urea, and the same volume of water to the other serving as the control. After thorough mixing, all the samples were dried up beforehand by keeping 2 hours at 100°C. and submitted afterwards to additional heating of 1 hour at various temperatures between 100~135°C. specified to each one of these samples. The samples were weighed of their dry matter, and their contents of urea and biuret* were also determined by extracting the dry matter with trich-

Table 1. The influence of heating temperature on the behavior of urea kept mixed with fish meat.

| Heating condition | Sample groups with urea | | | Control | |
|---|---|---|---|---|---|
| | Weight g. | Urea mg. | Biuret N mg. | Weight g. | Biuret N mg. |
| Before heating | 5.0000 | 84.50 | — | 5.0000 | 96.0 |
| 100°C., 2 hrs. | 1.5135 | 79.15 | 99.2 | 1.4925 | — |
| Additional heating | | | | | |
| 100°C., 1 hr. | 1.4289 | 66.81 | 94.9 | 1.3627 | 99.9 |
| 105 | 1.4176 | 70.42 | 89.0 | 1.3291 | 107.8 |
| 110 | 1.4158 | 56.90 | 88.0 | 1.3279 | 106.4 |
| 115 | 1.4090 | 58.32 | 82.0 | 1.3448 | 111.7 |
| 120 | 1.4079 | 49.83 | 81.7 | — | 108.7 |
| 125 | — | 48.41 | 77.5 | 1.3286 | 105.0 |
| 130 | 1.3777 | 29.39 | 65.8 | 1.3164 | 99.2 |
| 135 | 1.3729 | 24.68 | 45.2 | 1.3258 | 100.8 |

* The biuret was analysed electrophotometrically using 550 mμ filter of LUMETRON according to A. HILLER et al., J. Biol. Chem., **176**, 1421 (1948). Pure biuret was obtained by use of the method of VANINO., Praeparative Chemie, Org. Teil, pp. 221, for standardization.

loracetic acid solution. The results obtained are shown in Table 1.

Some notable points can be found prevailing among the data in the table: (1) the weight decrease of dry matter is larger if slightly for the meat samples with urea than for the control, (2) on the additional heating, while biuret reaction remains practically unchanged in the strength with the case of controls, it weakens rapidly in the sample group added with urea, and (3) an important portion of urea amounting even up to 70 per cent is attacked in the presence of fish meat, being in remarkable contrast to the case of pure urea (Table 2), where only 22 per cent of urea has been decomposed.

The question under what circumstances these points are given rise to may supposedly be accounted for as follows: First, the somewhat larger decrease in dry matter observed with the urea-added group may probably be due to the emergence of ammonia from the added urea. Secondly, the fact that not only the amount of urea but also the intensity of biuret reaction decreases with the rise of heating temperature seems to suggest that urea enters into interaction with biuret-giving materials of meat, through which it disappears from the system. The third point that the portion in which urea is attacked is far larger in the presence of fish meat than in the pure state may also certainly be ascribable to the same conditions as just mentioned.

Table 2. Decomposition of pure urea by heatihg. 5 ml. of about 16% solution of pure urea were taken into weighing tubes and heated at 100°C. for 2 hours, and additionally at 100° or 135°C. for 1 hour.

| Heating condition | Weight after heating mg. | Urea mg. | Biuret N mg. | Remarks |
|---|---|---|---|---|
| Before heating | — | 838.8 | 1.24 | |
| 100°C., 2 hrs. | 872.9 | — | 6.81 | |
| Additional: | | | | |
| 100°C., 1 hr. | — | 783.8 | — | |
| 135°C., 1 hr. | 830.6 | 653.1 | | Strong offensive smell of ammonia during heating; about 22 % of urea disappeared. |

**Exp. 3.** In order to verify the validity of the above interpretation a series of tests were carried out as follows in which urea damage effected by several typical matters was investigated for which marked differences in the interaction with urea are well expected to appear: Flesh of frigate-mackerel (A), shark-fish *Carcharhinus japonicus* (T. & S.) (B), peptone (C), meat-extract (D), egg-albumin (E) and dextrin (F) were employed separately but all in the state of some 75 per cent aqueous solution. Two groups of samples, the one without and the other with the addition of urea up to about 1.7 per cent, were prepared with these materials. Both the groups were treated subsequently in just the same way to each other, viz., they were first dried at 105°C. for 150 min. and additionally at 135~138°C. for 60 min. The urea was determined as usual, and the intensity of biuret-color and the position of the band of maximum absorption were read by means of Beckman's spectrophotometer (Table 3 and Fig. 5).

Table 3. Decomposition of urea, mixed with various substances, by heating.

| Mark of sample | Substance | Urea | | | |
|---|---|---|---|---|---|
| | | Before heating mg. % | After heating mg. % | Decomposed amount mg. % | Ratio of decomposition % |
| A | Frigate-mackerel | 1,608 | 510 | 1,089 | 68.6 |
| B | Shark-fish | 1,430 | 201 | 1,229 | 85.9 |
| C | Peptone | 1,699 | 0 | 1,699 | 100 |
| D | Meat-extract | 1,699 | 214 | 1,485 | 87.4 |
| E | Egg-albumin | 1,650 | 846 | 804 | 48.7 |
| F | Dextrin | 1,699 | 980 | 719 | 42.3 |

The photometry data obtained with pure biuret are also recorded in the same figure as standard.

We can find some remarkable affairs among these data. First, some marked differences in the rate of decomposition of urea have been induced by the substances together with which urea was dissolved, notwithstanding that both water content and heating condition were identical for all samples. Larger amount of urea was decomposed along the following series: Peptone>meat-extract>shark-fish meat>frigate-mackerel meat>egg-albumin>dextrin. On the other hand, as shown in Fig. 5, the differences in optical density between urea added group and control, which were caused by heating, ranked in the following order: Peptone (−0.086)>frigate-mackerel meat (−0.086)>meat-extract (−0.076)>dextrin (−0.018)>egg-albumin (+0.010). Thus, excepting the case of eggalbumin, the biuret color to be developed was reduced more or less strongly by the addition of urea*. It should be noticed here that, as seen with peptone as well as with meat-extract, the stronger biuret reaction corresponds to the larger consumption of urea. From these two results it will be

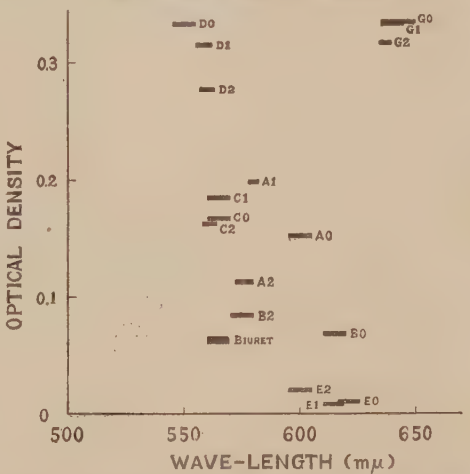


Fig. 5. Changes in absorption maximum and the optical density read at the absorption maximum of the biuret color. Biuret color was let to develop for some lots of substances: A~F are marks of substances as shown in Table 3. 0, 1, and 2 indicate the groups, added with urea but not-heated, urea-free but heated, and urea-added and heated, respectively.

* In the case of shark-fish, *Carcharhinus japonicus* (T. & S.), the optical density of heated group is of a slightly high level than that of unheated one; but it is a case impertinent to be compared because of the difficulty in preparing a urea free sample of this meat.

obvious that a considerable part of urea is spent in its interaction with some other compounds. However, in spite of that urea can thus attack on heating mother substances of biuret, there is also another implication that it behaves itself as a parent body of biuret. Thus, as seen also in this figure, the change in optical density observed for aqueous solutions of various substances, which is brought about by previously heating these substances together with urea, has been found to be always accompanied by a shift of maximum absorption band towards the position corresponding to biuret. Such drift of absorption band has occurred with special remarkableness in the case of egg-albumin, but, as to the degrees of both biuret formation and urea consumption, it seems likely that similar results are attained independent of whether the protein is treated with urea before or after its coagulation which is effected by heating for 10 min. on a boiling water bath.

It is also taken notice of that the once developed biuret color became faded most readily in the case of bonito-fish and frigate-mackerel.

## Discussion

In explaining the heat-decomposition of urea, WERNER[3] has proposed an equation

$$NH_2CONH_2 = NH_3 + HOCN\ ,$$

and pointed to that the cyanic acid here produced forms through polymerization cyanuric acid on the one hand, and also biuret on the other through its combination with free urea. In general, for the formation of biuret

$$2(NH_2CONH_2) \rightarrow NH_2CONHCONH_2 + NH_3 \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

and for the cyanuric acid formation

$$3HOCN \rightarrow N_3C_3O_3H_3 \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

or

$$NH_2CONHCONH_2 + NH_2CONH_2 \rightarrow N_3C_3O_3H_3 + 2NH_3 \quad \ldots\ldots\ldots\ldots (3)$$

have been accepted, respectively. NUKADA[4], from his observation that gaseous ammonia and carbon dioxide emerged vividly when 30 per cent solution of urea was heated under reduced pressure, and furthermore biuret reaction is positively developed during and after the time of crystallization, emphasizes that besides the reaction given by equation (1), also takes place the reaction

$$NH_2CONH_2 \rightarrow CO_2 + 2NH_3\ . \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

According to our attainment, as shown in Table 1, it is clear that there prevails at least the reaction given by equation (1), because both biuret and ammonia have been ascertained of their formation.

The decomposition temperature is also in good agreement with that given by NUKADA. In connection with this, it is likely that vaporization of thus formed ammonia, as well as that of free volatile bases existing from the start in the muscle of fish, results in a diminution of the dry matter; such tendency is to be decisively anticipated for the muscle of shark-fish. It may be quite defective, however, to attribute the decrease in dry matter wholly to such loss of ammonia and volatile bases.

Our present assumption that urea enters into combination with reactive groups of biuret-formable substances* remains yet to be taken not entirely granted for.**

To be described finally, we have arrived, from the results obtained on the biuret-active substances thus far examined, at the opinion that each of the said substances develops its specific color presumably corresponding to the length of carbon chain[7].

## Summary

(1) The heat-decomposition of urea in the muscle of shark-fish have been investigated because it seems responsible for the steady decrease of dry matter usually found upon the moisture determination by usual heat-drying method.

(2) The urea content of the muscle of shark-fish begins to decrease on heating already even at as low a temperature as 80°C.

(3) This decrease may be caused by the condensation of urea with other co-existing substances as well as by its conversion to biuret as inferred from the result of experiments made with different materials such as fish meat (bonito-fish and frigate mackerel), peptone, meat-extract, egg-albumin, and dextrin.

(4) If the muscle of shark-fish is dried by heating, its volatile basic constituents including free ammonia are partially evaporated resulting in a further loss of dry matter.

## Acknowledgment

The authors thank Dr. H. Hirano for his offerring active aid in completing the present manuscript.

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* Among these substances, tripeptide, diamide, histidine, and etc. may constitute very popular examples.

** In connection with this description, it is said that urea is possible to condense directly with carbohydrates[5][6].

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# TEST CULTURE OF SOME MICROORGANISMS WITH WHALE MEAT EXTRACT

Yutaka Sekine, Yukio Iwata and Tsuneo Ide

(Received March 6, 1954)

## Introduction

Main nutrient materials for microorganisms are meat extract of cow or of horse and peptone. However, it does not pay to use cow or horse meat as it is quite expensive, especially in case a large quantity of culture media is required. It is, therefore, used only for special tests and studies. In the past various kinds of meat extract were devised as substitute for cow or horse meat extract. Most of them were animal, though plant meat extract was also tested by some people. Most of animal meat extract is of marine animals including sardine[1], mackerel[2], bonito[3], oyster[4] and chrysalis[5], while the plants include laminaria[6], vegetables[7] and soy beans[8].

Meat extract which is on sale at present and used commonly is made of sardine or mackerel which serves as proper culture media for bacteria.

We, therefore, thought of meat of whales which are caught in large quantities and cheaper as compared to cow or horse meat. It would be advantageous if whale meat extract which is disused in the process of whale meat canning could be utilized as culture media for bacteria. In this view, we made experiments on the value of whale meat extract and disused meat extract as culture media in comparison with horse meat extract and tunny meat extract. We further compared Ehrlich meat extract on sale and pasty whale meat extract which was made of condensed meat extract. This report is on the result of these experiments. The experiments were carried out with horse meat extract as control. As tunny meat extract is discarded in the process of canning of tunny meat with oil or salt, tunny meat extract was compared to the whale meat extract, too.

## I. Experimental Procedure and Results.

1) Preparation of meat extract.

a. Horse meat extract: To horse meat distilled water in the quantity twice as much as the meat was added, which was boiled for 1 hour and filtered.

b. Tunny meat extract: Tunny meat was treated by the same method as mentioned above.

c. Whale meat extract: Red meat of Fin whale (Balaenoptera physalus (Linné)) was treated by the same method as above.

d. Disused whale meat extract: Whale meat extract disused in the process of whale meat canning. About 900 kg. of whale meat was put in a report of $4\times5\times6$ feet, to which 80% water was added. Steam power of 1 pound was

applied, and when the temperature got up to 90–100°C, meat extract was boiled for 1 hour.

2) Comparison of chemical composition of meat extract.

It is necessary for culture media to contain large quantities of nitrogen which is indispensable for existence and growth of living thins. First of all the quantity of total nitrogen was determined for comparison. The results are as follows:

Table 1. Comparison of Chemical Composition of Meat Extract.

| Extract | Chemical Composition (%) | | | |
|---|---|---|---|---|
| | Moisture | Dry-Matter | Total-Nitrogen | Total N Dry-Matter |
| Hourse | 98.20 | 1.80 | 0.16 | 8.93 |
| Tunny | 94.34 | 5.66 | 0.76 | 13.51 |
| Whale | 98.61 | 1.39 | 0.19 | 13.46 |
| Whale (disused extract) | 99.28 | 0.72 | 0.08 | 11.27 |

Result: The fact that tunny meat extract contains dry matter and total nitrogen in larger quantities compared to the other kinds of meat extract shows that it is superior to the others in its composition. Disused whale meat extract, on the other hand, consists largely of $H_2O$, and the total nitrogen content is 0.08%, worst of all the others as the source of nutrition.

There is little difference between whale meat extract and horse meat extract. The former is a little better than the latter as source of nitrogen which is indispensable for bacteria.

3) Amino Acid.

All microorganisms make use of amino acids for breeding. Amino acids

Table 2. Amino Acids in Each Meat Extract.

| Amino acid | Meat Extract | | | | Condensed Meat Extract | |
|---|---|---|---|---|---|---|
| | Horse | Tunny | Whale | Whale (Disused) | Whale | Ehrlich |
| Glycine | − | + | + | + | + | + |
| Alanine | ++ | + | ++ | ++ | ++ | ± |
| Carnosine | ± | + | + | − | − | − |
| Serine | + | + | ± | ± | + | + |
| Valine | − | ± | ± | ± | − | − |
| Leucine | − | ± | ± | ± | + | + |
| Aspartic acid | − | − | − | − | − | + |
| Glutamic acid | + | + | + | + | + | − |
| Lysine | − | − | ± | + | ± | ± |
| Cystine | − | − | + | + | + | + |
| Histidine | − | ++ | + | ± | + | ++ |

are decomposed very quickly. In some cases these amino acids are used for composition of bacterial protein. We, therefore, examined amino acids contained in these different kinds of meat extract by paper chromatography.

Result: The kinds of amino acids contained in horse meat extract are very few as compared to the other meat extract. The contents of Lysine and Cystine in tunny meat extract are smaller than that in whale meat extract. Among these 3 kinds of meat extract, whale meat extract contains many kinds of amino acids, especially Alanine in large quantity. From this fact it is learned that whale meat extract is a good source of nutrition for bacteria.

4) Comparison of growth of bacteria in liquid culture media. (meat extract and bouillon)

a. Culture media used for the experiment.

Meat Extract: 0.5% NaCl was added to each meat extract, which was heated and dissolved, and pH was adjusted to 7.0.

Bouillon: To each meat extract 0.5% NaCl and 1% peptone were added, which was heated and dissolved, and pH was adjusted to 7.0.

b. Experimental method.

2.0 mg. of different kinds of bacteria used for the test which were cultured for 20 hours were mixed in 10.0 ml. of 0.85% NaCl solution, and 0.1 ml. of it was inoculated in each meat extract and bouillon for culture in certain hours. Growth of bacteria was compared by turbidity of culture media.

Table 3. Comparison of Bacterial Growth in Liquid Culture Media.

| Strain | V. cholerae | | | | B. typohsus | | | | B. dysenteriae | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Meat extract | M. Ext. | | Bouillon | | M. Ext. | | Bouillon | | M. Ext. | | Bouillon | |
| Cult. hrs. / Meat | 24 | 48 | 24 | 48 | 24 | 48 | 24 | 48 | 24 | 48 | 24 | 48 |
| Horse | + | ++ | ++ | ++ | + | ++ | ++ | +++ | + | + | ++ | +++ |
| Tunny | ++ | +++ | ++ | +++ | ++ | +++ | ++ | +++ | ++ | ++ | ++ | +++ |
| Whale | ++ | ++ | ++ | +++ | + | ++ | ++ | +++ | + | + | ++ | +++ |
| Whale (disused m. ext.) | + | ++ | ++ | +++ | + | ++ | ++ | +++ | ± | + | ++ | ++ |

| Strain | Pseud ovalis | | | | Staphyloc. aureus | | | |
|---|---|---|---|---|---|---|---|---|
| Meat extract | M. Ext. | | Bouillon | | M. Ext. | | Bouillon | |
| Cult. hrs. / Meat | 24 | 48 | 24 | 48 | 24 | 48 | 24 | 48 |
| Horse | + | +++ | ++ | ++ | ± | ++ | ± | ++ |
| Tunny | ++ | +++ | ++ | ++ | + | ++ | + | ++ |
| Whale | ++ | +++ | ++ | ++ | + | ++ | + | ++ |
| Whale (disused m. ext.) | + | +++ | ++ | ++ | − | + | ± | ++ |

Results: Growth of bacteria is best in tunny meat extract, followed by whale, horse, and disused whale meat extract. In form of bouillon there was found little difference among those 4 different kinds of culture media. Growth of

Staphyloc. aureus was unfavorable in any of the 4 kinds of media. However, there was a notable difference among the four when the bacteria were cultured for 24 hours. With Pseud. ovalis, 3 kinds of meat extract, except tunny meat extract, assumed green color after 18 hours' culture.

5) Comparison of growth of bacteria on solid culture media. (Growth on bouillon plate agar)

a. Culture media used for the experiment.

2.5% agar was added to each bouillon, which was heated and dissolved, and it was adjusted to pH 7.0. After it was filtered, 15.0 ml. of it was poured in a Petri dish and made into plate agar.

b. Experimental method.

Each kind of bacteria was diluted in NaCl solution (0.85%) to make easy for calculation and 0.1 ml. of it was dropped on the plate agar. After it was smeared and cultured evenly, the number of colonies was counted accurately.

Table 4. Comparison of Growth of Bacteria on plate Agar Media. (Average of 3 tests)

| Strain \ Cult. media | Horse | Tunny | Whale | Whale (Disused extract) |
|---|---|---|---|---|
| V. cholerae | 750 | 1,100 | 750 | 650 |
| B. typhosus | 350 | 450 | 350 | 350 |
| B. dysenteriae | 200 | 210 | 190 | 180 |
| Buct. prodigiosum | 600 | 750 | 550 | 600 |
| Pseud. ovalis | 300 | 180 | 220 | 250 |
| St. aureus | 200 | 200 | 170 | 160 |

Result: Roughly speaking, tunny was best of all the other media, though there were some differences depending on the kind of bacteria cultured. The disused whale meat extract was inferior to the others. As this experiment was carried out with media made of bouillon and agar, its result was same as that of the Experiment 4. When peptone is added to meat extract to be made into bouillon, defects of meat extract are coverd by peptone, and little difference according to materials of media is recognized in that case.

6) Comparison of condensed meat extract.

a. Comparison of meat extract and bouillon.

As the experimental method is as same as stated under the Experiment 4 (liquid culture media), it is omitted here. Whale meat extract used for the experiment was made of condensed meat extract which was prepared by the method stated under the "Experimental Procedure."

Result: Whale meat extract is best of all the others for culture of B. typhosus for 24 hours. There was little difference among the different culture media in form of bouillon. When bouillon contains peptone, growth of bacteria is favorable. There was no big difference between the whale meat extract and Ehrlich

Table 5. Comparison of Condensed Meat Extract.

| Extract & Bouillon | Meat Extract | | | | Bouillon | | | |
|---|---|---|---|---|---|---|---|---|
| Condensed Extract | Whale | | Ehrlich | | Whale | | Ehrlich | |
| Strain \ Cult. hrs. | 24 | 48 | 24 | 48 | 24 | 48 | 24 | 48 |
| V. Cholerae | − | + | − | + | ± | ++ | ± | ++ |
| B. typhosus | + | + | − | + | + | +++ | ++ | +++ |
| B. dysenteriae | − | + | − | + | + | + | + | + |
| Bact. prodigiosum | + | ++ | + | ++ | ++ | +++ | + | ++ |
| Pseud. ovalis | + | ++ | + | ++ | ++ | ++ | ++ | ++ |
| Staphyloc. aureus | − | + | − | + | ± | ++ | ± | ++ |

meat extract. When meat extract itself and condensed meat extract are compared, the latter is inferior to the former for growth of bacteria.

## Conclusion

We carried out the experiments mentioned above in order to find whether whale meat extract and its disused meat extract made in the process of canning could be used as culture media for bacteria in comparison with horse meat extract and tunny meat extract. We also compared whale meat extract made from condensed whale meat extract and Ehrlich meat extract on sale. As the result of these experiments, we reached the following conclusion:

1) As a result of the experiments with various kinds of bacteria, it was found out that whale meat extract is inferior to tunny meat extract, but is as good as horse meat extract as culture media for bacteria.

2) Disused whale meat extract (made in the process of canning) is graded lowest of all the others due to the fact that nitrogen content is small because the hours of heating in the canning process are too short.

3) Condensed whale meat extract is as good as Ehrlich's meat extract.

In short, Condensed whale meat extract and not condensed serve as proper culture media for bacteria.

In closing we wish to thank gentlemen at the Taura Factory of Taiyo Gyogyo Kaisha for providing us with the material for the experiments.

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# VALUE OF WHALE MEAT PEPTONE AS CULTURE MEDIA FOR BACTERIA

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## Introduction

The principal materials of culture media for bacteria are meat extract and peptone. Though chemical composition of peptone is not clear, it is one of the most important materials as culture media with the source of effective organic nitrogen and of carbon.

Peptone has a remarkable influence upon growth of microorganisms. It is important, however, that it must contain various kinds of free amino acids in large quantities which are indispensable for growth of microorganisms. It is necessary for peptone to contain large quantities of various kinds of amino acids not only as the source of nutrition for bacteria but also to be used as culture media for diagnosis of bacteria.

The main brands of peptone on sale at present are Teruuchi, Poly and Witte. This report was written on the value of whale meat peptone as culture media for bacteria which has been made clear as a result of experiments carried out by the writers in expectation that peptone made of meat of whales caught in the Antarctic Ocean in large quantities might be used as better culture media for bacteria as compared to the peptones on sale, whereby utility of whale meat could be increased and at the same time cheap peptone could be obtained.

The study was started for the purpose of making peptone by having enzyme of the whale stomach digest whale meat, but as it was impossible to get the whale stomach, the stomach of a pig was used as substitute.

## I. Literature

Many studies have already been made on peptone as culture media Notable studies among them are as follows:—

S. Akiya (1948)[1] the mucous membrane of the whale stomach is dipped in acetone for 10 days (about 5.0% acetone) and fat of minced stomach is removed and dehydrated in 2–3-fold quantity of acetone. It is then dried in mixture of acetone-ether (1:1) to produce pepsin of the whale stomach. Tryptase is produced from the whale pancrease by the same method as mentioned above.

Y. Ishikawa (1949)[2], (1950)[3] made experiments on enzyme decomposed protein of the whale pancrease. He confirmed that enzyme was of trypsin type and determined the optimum pH and enzyme ability.

S. Tsukamoto (1949)[4] devised a method of producing peptone by having Koji-mould (aspergillus oryzae) digest frozen whale meat. He reported that the most suitable temperature for digestion is about 42°C and the hours 120 hours.

M. Takaoka (1944)[5], (1949)[6] (1950)[7] made experiments on protease of stomach of different kinds of marine animals, and confirmed that it differs from that of land animals. He made pepsin out of the whale stomach and determined enzyme ability.

## II. Experimental Procedure

1. Preparation of whale meat peptone

Red meat of stale Fin whale (Balaenoptera physalus Linne) which had been used for freezing experiments was minced with a chopper. To 1,355 g of whale meat thus prepared 542 g of chopped pig stomach (40% of whale meat) and 2.7 liter of luck distilled water (double the quantity of meat) were added and stirred well to make it pH 2.0 with 5% HCl. (About 700 ml. of 5% HCl is required.) It was put in an incubator of 45°C in order for the meat to be digested in certain hours (72 hours and 120 hours). Transparent part of the middle layer was taken in a siphon and boiled for 30 minutes on water bath to decompose enzyme. It was adjusted to pH 5.0 with 20% NaOH solution, and filtered with flannel first and filter paper next. The filtrate was evaporated and concentrated on water bath until it turned pasty. It was left for a while to be cooled and solidified, and was crashed in a mortar to make peptone.

By this method the following peptones were obtained:

72 hours Solution for digestion 1.0 liter 80.5 g...K. 1
120 hours 〃 〃 〃 2.9 〃 273.5 g...K. 2

Whale meat extract used for the experiment was made by the following method: Red meat is minced, to which distilled water is added in the quantity twice as much as the meat. The solution is boiled for 2 hours and filtered. The filtrate (pH 5.8) is concentrated on water bath, to which NaCl is added by 3%.

Poptones used for comparison were: (1) Poly peptone (P); (2) Teruuchi peptone (T); (3) Witte peptone (W).

2. Comparison of chemical components of different kinds of peptones

Table 1. Percentage of Chemical Analysis of Whale and Market Peptones.

| Peptone | Total Nitrogen | Non-Precipitated Nitrogen CCl cooH | Precipitated Nitrogen by $CCl_3$ cooH | Non-Precipitated Nitrogen by Tannic acid | Peptone Nitrogen | Amino Nitrogen | Ash | pH |
|---|---|---|---|---|---|---|---|---|
| K. 1 | 13.17 | 12.75 | 0.42 | 6.15 | 6.60 | 2.29 | 5.83 | 5.09 |
| K. 2 | 13.09 | 12.72 | 0.37 | 6.55 | 6.17 | 2.71 | 5.76 | 4.94 |
| Poly | 14.86 | 14.00 | 0.86 | 10.58 | 3.42 | 5.72 | 5.77 | 6.54 |
| Teruuchi | 13.35 | 12.99 | 0.36 | 10.13 | 2.86 | 4.98 | 9.93 | 5.86 |
| Witte | 15.16 | 14.28 | 0.88 | 3.34 | 10.94 | 1.94 | 1.48 | 7.08 |

Remarks: Above figures indicate percentage against dry matter. Amino Nitrogen was determined by the Van Slyke Method. After 1% peptone solution was boiled in a koch for 40 minutes and after it has been called, pH value was determined by Beckman glass electrode.

a. Chemical analysis of peptone.

In order to compare and clarify chemical composition of K. 1 and K. 2 and the other peptones on sale, the quantity of different kinds of nitrogen was determined mainly. The result is as Table 1.:

Result: As shown in Table 1, peptone nitrogen is contained in the highest quantity in Witte, followed by K. 2 and K. 1, its content is very small in Poly and Teruuchi, being only 1/4–1/5 of total nitrogen. It shows that a greater part of Poly and Teruuchi consists of molecules lower than peptone. Therefore the content of amino nitrogen is just contrary. Amino nitrogen contained in Witte is about 1/8 of total nitrogen. From these contents it is imagined that a similar thing can be said with free amino acid content also. Ash content is highest in Teruuchi and lowest in Witte. Therefore it is unsuitable as a source of inorganic matters.

b. Composition of amino acids in peptone.

Amino acid composition was analyzed by paperchromatography to detect amino acids indispensable for bacteria.

In order to detect tryptophan, the solution was boiled and decomposed with $Ba(OH)_2$.

Table 2. Amino Acids in Peptone Hydrolyzed by HCl and $Ba(OH)_2$.

| Amino acid \ Peptone | K 1 | K 2 | Poly | Teruuchi | Witte |
|---|---|---|---|---|---|
| Alanine | ## | ## | ## | + | ## |
| B-Alanine | ∓ | ∓ | − | ∓ | ± |
| Aspartic acid | ## | ## | ## | ## | ## |
| Cystine | ## | ## | ± | ± | + |
| Glutamic acid | ### | ### | + | ### | ### |
| Glycine | ## | ## | ### | + | ### |
| Leucine | ## | ## | ## | ## | + |
| Proline | + | ## | ## | ## | + |
| Serine | ## | ## | ## | + | ## |
| Taurine | + | + | ### | ∓ | − |
| Threonine | + | + | + | + | + |
| Tryptophan | ± | ± | + | + | ## |
| Tyrosine | + | + | ## | ## | + |
| Valine | + | ## | ## | + | + |
| Arginnine | ## | ## | | | + |
| Lysine | | | + | + | |
| Histidine | + | + | | | + |
| Ornithine | ## | ## | | | ± |

Result: In the solutions of different kinds of peptone, almost the same kinds of amino acids are contained. But Poly does not contain B-Alanine and Witte not Taurine.

Whale peptone contains Cystine in larger quantity as compared to the other peptones, but Tryptophan content is very small, just contrary to the other peptones. It is inferred that whale peptone is suitable for $H_2S$-forming ability test but not for Indole reaction test,

c. Free amino acids in peptone.

Free amino acids which are indispensable for growth of bacteria were analyzed by paperchromatography.

Experimental method: 1.0 g of each peptone was dissolved in 10 ml. of distilled water, to which 30 ml. absolute alcohol was added slowly to precipitate peptone. The precipitate was filtered, and the filtrate was transferred in an evaporation plate, which was heated on water bath to remove alcohol. It was filtered two or three times in this process. 0.1 ml. of amino acid solutions of the different kinds of peptone which were concentrated evenly were spotted on filter paper by a micropipette. Next procedure to detect free amino acids is as same as mentioned above.

Table 3. Free Amino Acids in Peptone.

| Amino acid \ Peptone | K. 1 | K. 2 | Poly | Teruuchi | Witte |
|---|---|---|---|---|---|
| Alanine | + | + | ++ | + | + |
| B-Alanine | − | − | − | − | − |
| Aspartic acid | + | ++ | + | − | + |
| Cystine | − | − | − | − | − |
| Glutamic acid | ± | + | ++ | + | ± |
| Glycine | ± | ± | ++ | ∓ | ± |
| Leucine | ++ | ++ | ++ | + | + |
| Proline | − | − | + | − | − |
| Serine | ∓ | ∓ | + | + | − |
| Taurine | − | − | − | − | − |
| Threonine | − | − | + | ∓ | − |
| Tryptophan | ∓ | ∓ | ∓ | ± | ∓ |
| Tyrosin | + | + | − | + | − |
| Valine | − | − | ++ | − | ± |
| Arginine | + | + | | − | |
| Lysine | + | + | ++ | ++ | ± |
| Histidine | + | + | ++ | − | |
| Ornithine | | + | | | |

Result: Poly peptone is superior to the other peptones in that it contains various kinds of free amino acids in large quantities as compared to the others. Following Poly are K. 2 and K. 1, and the content of free amino acids in Witte is smallest of all. From this fcat it can be iamgined that Witte is unsuitable for growth of bacteria, for it is considered that most of bacteria grow with such low molecules as free amino acids, and after that they decompose and take peptone. The content of free amino acids is higher in Poly and Teruuchi and

low in Witte. A greater part of Witte consists of peptone, as shown in Table 1.

d. Comparison of Tryptophan content by Adamkiewicz' Reaction.

For an Indole reaction test, peptone must contain Tryptophan. The higher its content is, the better it is for the reaction. An experiment for comparison of its content, therefore, was made by the above method.

Table 4. Tryptophan in Peptones.

| K. 1 | K. 2 | Poly | Teruuchi | Witte |
|---|---|---|---|---|
| + | + | ++ | ++ | +++ |

Result: Tryptophan content was highest in Witte peptone, but it was very small in K. 1 and K. 2 as compared to the other peptones. This conforms to what is indicated in Table 2 and 3. It is considered that Indole-forming test is also in the almost same order as this.

3. Liquid media

In order to examine the value of different peptones as culture media, a comparative study was made on growth of bacteria in different peptone solutions which are commonly used for comparison of growth of bacteria, biological test, in other words Indole reaction test, nitrates reduction test or as culture media of Barsiekow or Vibrio cholerae.

a. Culture media used for the experiment.

10.0 g peptone and 5.0 g NaCl were dissolved in 1 liter of $H_2O$, which was adjusted to pH 7.0. The precipitate of Witte only was filtered and 10 ml. of it was separated in a sterilizing tube then sterilized it.

b. Bacteria samples.

(1) Vibrio cholerae
(2) B. dysenteriae
(3) B. typhosus
(4) E. coli
(5) Prot. vulgaris
(6) B. mesentericus vulgatus
(7) B. natto
(8) Staphyloc. aureus
(9) Bact. prodigiosum
(10) Pseudo. ovalis

c. Experimental method.

2 mg of all of the above-mentioned bacteria which were cultured for 24 hours were diluted in 10 ml. of 0.85% NaCl solution. Thus even bacteria solutions were prepared. 0.1 g of the bacteria was added to each of the different peptone solutions and bacteria numbered (1) through (7) were cultured at 35°C and (8)–(10) at 25°C. They were taken out of the solutions at certain hours in order to compare their growth.

Result: K. Poly and Teruuchi were similar as to their favorable influence on growth of bacteria. It is assumed that they are rich in nutrition for microbes. Witte, on the other hand, is very unfavorable for growth of bacteria. It is not good as the source of nutrition for microbes.

Table 5. Comparison of Growth of Bacteria in Peptone Solutions.

| Culture hrs. | 24 | | | | | 48 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Strain \ Peptone | K. 1 | K. 2 | P | T | W | K. 1 | K. 2 | P | T | W |
| V. cholerae | ## | ## | ## | ## | + | ## | ## | ## | ## | + |
| B. dysenteriae | ## | ## | ## | + | ± | ## | ## | ## | ## | + |
| B. typhosus | + | + | + | + | ± | ## | ## | ## | ## | + |
| E. coli | ## | ## | ## | ## | + | ## | ## | ## | ## | + |
| P. vulgaris | + | + | + | + | ± | ## | ## | ## | ## | ± |
| B. mesentericus | + | + | + | + | ∓ | ## | ## | ## | ## | ∓ |
| B. natto | + | ## | + | ## | ± | ## | ## | ## | ## | + |
| St. aureus | ± | + | + | + | ± | + | + | ## | ## | + |
| Bact. prodigiosum | + | + | ## | ### | + | ### | ### | ### | ### | ## |
| Pseud. ovalis | ## | ## | ### | ### | + | ### | ### | ### | ### | ## |

4. Comparison of growth of bacteria on solid media

a. Growth on peptone plate agar (meat extract not contained). (Comparison by the number of Bacteria).

The degree of dilution convenient for calculation of colonies of the different kinds of bacteria growing on a plate was determined preliminarily. 0.1 ml. of bacteria was coated and cultured on the plate to count the number of bacteria accurately. The value of peptone was determined according to the number of growing colonies.

b. Culture media used for the experiment.

To 1.0% peptone, 0.3–0.5% NaCl was added, which was heated for dissolution and adjusted to pH 7.2. 15 ml. of the solution was poured in a Petri dish for a plate culture.

Table 6. Comparison of Bacteria Number on Peptone Plate Agar.

| Strain \ Peptone | K-1 | K-2 | P | T | W |
|---|---|---|---|---|---|
| V. cholerae | 10 | 40 | 20 | 20 | 10 |
| B. dysenteriae | 70 | 120 | 70 | 40 | 10 |
| B. typhosus | 140 | 150 | 170 | 170 | 80 |
| E. coli | 60 | 60 | 70 | 60 | 40 |
| P. vulgaris | 350 | 250 | 310 | 220 | 220 |
| St. aureus | 90 | 90 | 170 | 160 | 70 |
| Pseud. ovalis | 120 | 200 | 240 | 190 | 130 |

Result: K, Teruuchi and Poly showed similar results in solis media also, though there were found some differences according to the kind of bacteria. Witte was found inferior to the other peptones.

5. Value of peptones as culture media for bacteria diagnosis

a. Comparison of Indole forming test.

At test was made in order to find whether whale peptone was suitable for Indole forming ability test, one of the most important tests for diagnosis of bacteria.

(1) Experimental method.

Culture media were prepared by an ordinary method. 2 mg of the different kinds of bacteria were put in 10 ml. of NaCl solution (0.85%). 0.1 ml. of the emulsion thus prepared was inoculated into the respective peptone solutions. After culture for certain hours, reaction was examined by the Ehrlich method.

Table 7. Comparison of Indole-Forming Test.

a) V. cholerae

| Cult. hrs. | 24 | | | | 48 | | | | 72 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Peptone \ Observ. hrs. | 0 | 5 | 24 | 48 | 0 | 5 | 24 | 48 | 0 | 5 | 24 | 48 |
| K-1 | + | ++ | ++ | ++ | ± | + | ++ | ++ | ± | + | ++ | ++ |
| K-2 | + | ++ | ++ | ++ | ± | + | ++ | ++ | ± | + | + | ++ |
| Poly | + | ++ | ++ | ++ | ± | ++ | ++ | ++ | ∓ | ++ | ++ | ++ |
| Teruuchi | + | ++ | ++ | ++ | ∓ | + | ++ | ++ | ∓ | ++ | ++ | ++ |
| Witte | ± | ++ | ++ | ++ | ∓ | ++ | ++ | ++ | − | ++ | ++ | ++ |

b) B. dysenteriae (B III)

| Cult. hrs. | 24 | | | | 48 | | | | 72 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Peptone \ Observ. hrs. | 0 | 5 | 24 | 48 | 0 | 5 | 24 | 48 | 0 | 5 | 24 | 48 |
| K-1 | ∓ | + | ++ | ++ | − | + | + | ++ | − | ± | ++ | ++ |
| K-2 | ∓ | + | ++ | ++ | − | + | + | ++ | − | ± | ++ | ++ |
| Poly | + | ++ | ++ | ++ | ∓ | ++ | ++ | ++ | − | ++ | ++ | ++ |
| Teruuchi | + | ++ | ++ | ++ | − | ++ | ++ | ++ | − | ++ | ++ | ++ |
| Witte | ∓ | + | ++ | ++ | − | ± | + | ++ | − | + | ++ | ++ |

c) E. coli

| Cult. hrs. | 24 | | | | 48 | | | | 72 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Peptone \ Observ. hrs. | 0 | 5 | 24 | 48 | 0 | 5 | 24 | 48 | 0 | 5 | 24 | 48 |
| K-1 | ∓ | + | ++ | ++ | ∓ | + | + | ++ | ∓ | ± | ++ | ++ |
| K-2 | ∓ | + | ++ | ++ | ± | ++ | ++ | ++ | ∓ | ± | ++ | ++ |
| Poly | − | ++ | ++ | ++ | ∓ | ++ | ++ | ++ | − | ++ | ++ | ++ |
| Teruuchi | − | ++ | ++ | ++ | − | ++ | ++ | ++ | − | ++ | ++ | ++ |
| Witte | ∓ | + | ++ | ++ | − | + | + | ++ | − | + | ++ | ++ |

Result: Indole forming test varies with the kind of bacteria and hours of culture, but Poly and Teruuchi are superior to the other peptones in this respect.

Whale peptone showed the same Indole-forming ability with all of the different kinds of bacteria. K is superior to Witte and can be used for Indole test. Tryptophan content is higher in Witte than in K, but the former is unsuitable for Indole forming. It is considered that it is because of its poor source of nutrition.

b. Comparison of $H_2S$ forming test on lead acetate agar.

Some of bacteria reduce Cystine or Cysteine to $H_2S$. This also is used for diagnosis of bacteria, In order to carry out this test, culture media should contain these matters in certain quantities. Generally peptone contains some of these matters. In order to find whether K peptone could be used for $H_2S$ forming test, a study was made with K and other peptones for comparison.

(1) Culture media used for the test.

After 1.0% peptone, 0.5% of meat extract and 2.0% agar were dissolved and filtered, 5.0% lead acetate solution was added at the rate of 20% so that the solution was adjusted to pH 6.8. About 10 ml. of the solution was put in a test tube and used for the experiment after sterilization.

Table 8. Comparison of $H_2S$ Forming Test.

| Cult. hrs. | 24 | | | | | | 48 | | | | | | 72 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Peptone / Strain | K.1 | K.2 | KK2 | P | T | W | K.1 | K.2 | KK2 | P | T | W | K.1 | K.2 | KK2 | P | T | W |
| V. cholerae | + | + | + | ∓ | + | + | + | ++ | ++ | ± | + | ++ | ++ | +++ | +++ | ++ | ++ | +++ |
| B. typhosus | + | ++ | ++ | ± | ∓ | ++ | ++ | +++ | +++ | + | + | +++ | +++ | +++ | +++ | ++ | ++ | +++ |
| E. coli | + | ++ | ++ | ± | ± | ++ | +++ | +++ | +++ | + | ++ | +++ | +++ | +++ | +++ | ++ | ++ | +++ |
| Prot. Vulgaris | + | ++ | ++ | + | + | ++ | +++ | +++ | +++ | ++ | ++ | +++ | +++ | +++ | +++ | ++ | ++ | +++ |

Remarks: KK2-test with whale meat extract. Others-test with fish meat extract.

Result: Regardless of hours of culture, KK2 (whale meat peptone+whale meat extract) and Witte showed almost the same result, exceeding the others, followed by K. 2, K. 1, T and P in this order. This order is consistent with the order of cystine content in peptones roughly. (Table 2)

c. Comparison of pigment forming test on peptone slant agar.

Most of bacteria form different pigments. Source of nutrition is a necessity for formation of these pigments. In other words, nitrogen and other inorganic matters are required. Therefore, it is necessary to select culture media suitable for the pigment forming ability test. A test was carried out in this respect.

(1) Culture media used for the test.

Same as in the experiment 4. Agar culture medium with peptone only (without meat extract) was prepared which was slanted for culture of bacteria. Temperature for culture was 25°C and pH of culture media adjusted to 7.0 evenly. The result of a test on culture media with meat extract could not find the difference among each peptone, and therefore it was omitted here.

Table 9. Comparison of Pigment Forming Test on Peptone Slant Agar.

| Cult. hrs. / Peptone / Strain | 24 | | | | 48 | | | | 72 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | K. 2 | P | T | W | K. 2 | P | T | W | K. 2 | P | T | W |
| St. aureus | − | − | − | − | + | + | + | + | + | ++ | ++ | ++ |
| Bact. prodigiosum | ± | + | ± | ++ | ± | + | ± | ++ | ++ | ++ | ++ | ++ |
| Pseud. ovalis (1) | + | + | + | ∓ | ++ | ++ | ++ | ± | ++ | ++ | ++ | + |
| 〃 〃 (2) | + | + | + | − | ++ | + | ++ | − | ++ | ++ | ++ | + |
| Same. (2) | − | − | − | − | + | ± | + | − | ++ | + | ++ | − |

Result: Observing from the result of this test, Teruuchi peptone comes to the top of the others in pigment forming ability. K. 2 and Poly are almost the same. Witte only was found inferior in pigment forming ability. With Bact. prodigiosum, however, Witte showed a remarkable superior result. When meat extract is added, any peptone increases its pigment forming.

d. Comparison of nitrate reduction in peptone solution.

Some bacteria reduce nitrate to nitrite. This action is also one of the important tests for diagnosis of bacteria. As it is influenced greatly by the growth of bacteria, a comparative experiment was made on reduction of nitrate in different peptone solutions.

(1) Preparation of culture media and method of experiment were just ordinary.

Table 10. Comparison of Reduction of Nitrate in Peptone Solutions.

| Strain / Cult. hrs. / Peptone | V. cholerae | | | B. typhosus | | | E. coli | | | B. mesent vulgatus | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 24 | 48 | 72 | 24 | 48 | 72 | 24 | 48 | 72 | 24 | 48 | 72 |
| K-1 | + | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ |
| K-2 | ++ | ++ | ++ | + | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ |
| Poly | ++ | ++ | ++ | + | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ |
| Teruuchi | ++ | ++ | ++ | + | ++ | + | + | ++ | ++ | ++ | ++ | ++ |
| Witte | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ |

Result: Though there were found some differences depending on the kind of bacteria, all of the peptones showed almost the same reducing degree. Especially with V cholerae, Witte showed the greatest reduction after 24 hours' culture. With B. memsent, on the contrary, Witte was weakest, while the other peptones showed strong reduction after 24 hours.

## Conclusion

The following conclusion was drawn as a result of experiments on the value of whale meat peptone as culture media which were made by digestion of frozen whale meat of the Southern Ocean with enzyme of the pig stomach:

(1) The longer the hours of digestion of whale meat are, the larger the quantity of peptone obtained, and amino nitrogen content is higher, and therefore, it is good for growth of bacteria and also for special diagnosis tests. It has been confirmed that whale meat peptone is as good as the other peptones on sale. Proper hours for digestion are about 120 hrs.

(2) Whale meat peptone, both in form of liquid and solid media, proves its suitability on growth of various kinds of bacteria.

(3) As Tryptophan content is low in whale meat peptone, it is somewhat inferior to the other peptones in Indole forming test, but it can serve the purpose all right.

(4) It is superior to the other peptones on $H_2S$ forming test. It is especially suitable for the $H_2S$ forming ability test.

(5) Its pigment forming ability test is as same as that of the other peptones on sale.

(6) Its suitability for nitrate reducing ability test is as same as that of the other peptones on sale.

In short, whale meat peptone is as good as the other peptones on sale.

In closing the report, we wish to express our heartfelt thanks to Dr. Azuma, Chief of Research Department, Taura Factory, Taiyo Gyogyo Co., Ltd. and Mr. S. Nagayama of the same company for providing us with whale meat used for the experiments.

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# INCREASE OF VOLATILE BASIC NITROGEN AND GROWTH OF BACTERIA IN THE MUSCLE OF FISH AT THE EARLY STAGE OF SPOILAGE

Susumu Horie and Yutaka Sekine

(Received April 5, 1954)

## Introduction

Generally there are no bacteria in the muscular tissue of living fish. However, bacteria are found on the skin, digestive tracts, and the parts exposed to the (sea) water even when fish is alive. These bacteria increase rapidly after fish dies and invade into the muscular tissue finally, and thus they spoil and decompose the muscle.

In regard to the relation between freshness of fish and the number of bacteria, it has been believed that fish is at the early stage of spoilage if the number of bacteria in 1.0 g. of fish muscle reaches $10^5$–$10^6$. But for most of the experiments carried out so far in this regard, mashed or minced fish meat was used and its spoilage was accelerated in a heater with high temperature. Actually, however, such a condition does not occur, and so there is a large difference between the fish meat spoilt on purpose for these experiments and fish which are naturally rotten.

It is hard for bacteria on the surface of fresh fish to invade and breed in the muscle. Breeding rate of bacteria is different in the surface layer and in the middle layer of the muscle, and therefore the degree of spoilage is also different. We, therefore, kept some kinds of fish in their original form for several days to spoil them and took out a part of the muscle under the germ free condition to determine the number of bacteria in the muscle. This report is on an interesting relation between the number of bacteria and volatile basic nitrogen in the muscle at the early stage of spoilage.

## I. Experiment

### *A. Determination of pH, volatile basic nitrogen and the number of bacteria on the skin and in the layers of the muscle from the surface to the middle at the early stage of spoilage of Bonito.*

1) Test sample and method of experiment.

Bonitoes used for the experiment were very fresh and weighed each 1.5–2.3 kg. Among 5 bonitoes, one was used immediately for the experiment with fresh fish, and the rest of 4 were hung in a room.

A lump of meat of 10 cm length (see Fig. 1) was cut off with a sterilized knife from the back of the bonito. This meat was put on a wire gauze with the skin upside, and muscular sides were sterilized with flames. With the skin downward, the

lump of the meat was cut with a knife as shown in the Figure 1, and pieces of A., B. and C. layers were obtained. Each piece was 8–9 cm long and 7 mm thick. 1 g. at the center of each piece was used for determination of the number of bacteria. Both sides of the pieces were used for determination of pH and V.B.N. Plate agar contained 0.1% glucose was used for the determination of the number of bacteria. 0.1 ml. of the diluted solution was dropped on the plate agar which was smeared with a platinum loop.

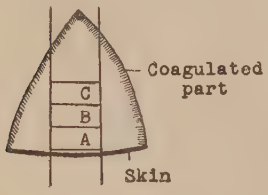


Fig. 1. Section of the meat.

V.B.N. was determined by the "Low Pressure and Distillation Method" in accordance with Hygienic Examinations Guide III[1] (P. 39–46) and pH was determined with Beckman's glass electrode.

2) Experimental results.

The results are as showed in the Table 1. Mark *O* shows the number of bacteria in 1 g. of the muscle and 1 $cm^2$ of the skin.

$000 = 10^3 - 10^4$ $\quad 0000 = 10^4 - 10^5$ $\quad \overset{0000}{0} = 10^5 - 10^6$

$\overset{0000}{00} = 10^6 - 10^7$ $\quad \overset{0000}{000} = 10^7 - 10^8$

△=The greater part of bacteria consists of fine colonies which are pale blue and semi-transparent.

V.B.N. was determined by mg. in 100 g. of muscle. pH and V.B.N. were determined with the muscle only. The table follows:

Table 1. Observation of Bonito at the Early Stage of Spoilage.

| Date | | 7/IX | 8/IX | 9/IX | 10/IX | 11/IX |
|---|---|---|---|---|---|---|
| Room-Temp. °C | | 28.1–21.2 | 24.8–21.3 | 25.5–21.0 | 25.0–20.4 | 23.5–20.5 |
| Moist. % | | 96.0 | 96.0 | 96.0 | 93.5 | 95.0 |
| Days elapsed | | 0 | 1 | 2 | 3 | 4 |
| Skin | No. of cells | 000 | $\overset{0000}{00}$ | $\overset{0000}{0000}$ | $\overset{0000}{000}$ | $\overset{0000}{000}$ |
| Muscle A | No. of cells | 000 | $\overset{0000}{0}$ | 0000 | 0000 | $\overset{0000}{00}$ △ |
| | V.B.N. | 20.1 | 23.0 | 43.0 | 54.8 | 90.3 |
| | pH | 5.51 | 5.76 | 6.37 | 6.53 | 6.51 |
| Muscle B | No. of cells | 000 | 000 | 000 △ | $\overset{0000}{0}$ △ | $\overset{0000}{0}$ △ |
| | V.B.N. | 24.2 | 26.9 | 43.1 | 50.9 | 87.7 |
| | pH | 5.52 | 5.76 | 6.36 | 6.43 | 6.47 |
| Muscle C | No. of cells | 000 | 000 | 000 △ | $\overset{0000}{0}$ △ | $\overset{0000}{000}$ △ |
| | V.B.N. | 28.5 | 34.3 | 41.8 | 50.2 | 87.8 |
| | pH | 5.42 | 5.74 | 6.28 | 6.36 | 6.38 |
| Spoilt odor | | − | ± | ＋ | ＋ | ＋ |
| Good .....O<br>No. Good....X as Food | | O | ? | X | X | X |

The experiment was made early in September when the temperature was comparatively high. The number of bacteria increases on the skin very rapidly, and one or two days later, it reaches the maximum. But the increase in the muscle is slow, and even after 2 days have elapsed and it is considered that fish must be spoilt by then, there is no remarkable increase in the number of bacteria in the muscle. There is little difference in V.B.N. and pH according to the layer of the muscle. The increase in the number of bacteria in Part A was earlier than the other Part slightly. V.B.N. content in the middle layer was high at the beginning of the experiment.

### *B. The number of bacteria in the muscle of Mackerel and Yellowtail at the early stage of spoilage.*

As the result of the experiment with the bonito muscle, it was learned that there is little difference in pH and V.B.N. according to the layer of fish muscle. Therefore, it is thought unnecessary to consider the distance of the muscle from the skin when the muscle is used for experiments.

The experiments were carried out with frigate mackerels and chub mackerels towards the end of September and with mackerels and yellowtails in the middle of October. The fishes were kept under the natural condition in room temperature for 4 days and 3–5 days respectively. The number of bacteria in the mucsle and V.B.N. and pH were determined.

1) Test sample and experiment method.

5 frigate mackerels and 5 chub mackerels were used for the experiment in September, and 5 each of yellowtails and chub mackerels were used for the experiment in October. The method of preparation of the test sample was same as that for the experiment with bonitoes. For determination of the number of bacteria about 1 g. of the muscle 7 mm below the skin was taken under the germ-free condition.

2) Experimental results: See Tables 2 and 3.

Table 2. Observation of Frigate Mackerels and Chub Makerels at the Early Stage of Spoilage.

| Date | | | 21/IX | 22/IX | 23/IX | 24/IX | 25/IX |
|---|---|---|---|---|---|---|---|
| Room-Temp. °C | | | 18.5–23.5 | 19.1–22.8 | 19.9–21.0 | 21.3–25.9 | 23.9–27.5 |
| Moist % | | | – | 92.5 | 98.0 | 93.5 | 97.2 |
| Days elapsed | | | 0 | 1 | 2 | 3 | 4 |
| Frigate Mackerel | No. of Cells | Mixed cult. | $0\times10^2$ | $5.3\times10^2$ | $1.0\times10^2$ | $38.0\times10^2$ | $0\times10^2$ |
| | | Smeared cult. | $0\times10^2$ | $12.3\times10^2$ | $6.0\times10^2$ | $6.0\times10^2$ | $24.3\times10^2$ |
| | V.B.N. mg/% | | 36.3 | 53.7 | 57.3 | 95.9 | 93.4 |
| | pH | | 5.63 | 5.97 | 6.00 | 6.49 | 6.51 |
| | Spoilt odor | | – | + | ++ | ++ | ++ |
| | Good .....O<br>No Good....X as food | | O | X | X | X | X |

| Date | | | 21/IX | 22/IX | 23/IX | 24/IX | 25/IX |
|---|---|---|---|---|---|---|---|
| Chub Mackerel | No. of Cells | Mixed cult. | $1.2\times10^2$ | $0.6\times10^2$ | $8.3\times10^2$ | $1.5\times10^2$ | $14.6\times10^4$ |
| | | Smeared cult. | $0\times10^2$ | $1.7\times10^2$ | $8.3\times10^2$ | $3.8\times10^2$ | $27.7\times10^4$ |
| | V.B.N. mg/% | | 24.1 | 20.3 | 36.6 | 98.8 | 237.7 |
| | pH | | 5.89 | 5.75 | 5.80 | 6.65 | 7.25 |
| | Spoilt odor | | − | ∓ | ∓ | ∓ | ∓ |
| | Good .....O<br>No good....X as food | | O | ? | X | X | X |

In spite of the fact that the fishes kept under the room temperature for 3 days in the end of September were found spoilt, there was observed no increase in the number of bacteria in the muscle. After 4 days bacteria were found increasing in chub mackerels for the first time.

As shown in the Table 3, both chub mackerels and yellowtails were completely spoilt as 4 days have elapsed, but there was found no increase in the number of bacteria.

Table 3. Chub Mackerels and Yellowtails at the Early Stage of Spoilage.

| Date | | 13/X | 14/X | 15/X |
|---|---|---|---|---|
| Room-Temp. °C | | 18.3–17.4 | 21.3–17.2 | 18.0–14.8 |
| Days elapsed | | 3 | 4 | 5 |
| Chub Mackerel | No. of Cells | $18.7\times10$ | $18.0\times10$ | $7.5\times10$ |
| | V.B.N. mg % | 50.6 | 102.2 | 95.0 |
| | pH | 6.32 | 6.75 | 6.22 |
| | Spoilt odor | ∓ | ∓ | ∓ |
| | Good.....O<br>No good.....X | X | X | X |
| Yellow-tail | No. of Cells | $57.6\times10$ | $37.2\times10$ | $73.8\times10$ |
| | V.B.N. mg % | 36.6 | 63.1 | 56.1 |
| | pH | 5.83 | 6.12 | 6.45 |
| | Spoilt odor | + | ∓ | ∓ |
| | Good.....O<br>No good.....X | X | X | X |

Room-Temp. °C:—10/X–12/X=22.0°C–16.7°C.

## II. Study

As the result of the experiments, it was clarified that when fish is left under the natural condition to be spoilt, the increase in the number of bacteria in the muscle is surprisingly slow. As show in the Tables 2 and 3, there was no remarkable increase in the number of bacteria even when V.B.N. reached

100 mg.%. From this fact, therefore, it is not right for us to think that a large quantity of V.B.N. is composed by bacteria which have entered the muscle and increased there. V.B.N. composed by bacteria which increase rapidly in the gut or on the skin penetrates into the muscle physically or the enzyme composed by bacteria which have increased in these parts enters the muscle and decomposes it, whereby V.B.N. is composed. Or these two factors work on composition of V.B.N. together.

According to K. Amano[2], the increase in the quantity of $NH_3$ in the fish muscle reaches 20 mg% independent of bacterial growth after the death of fish. In this experiment, V.B.N. was composed in large quantity, though it is not clear to which of the 3 processes mentioned above this composition of V.B.N. we would be allowed to think that is due to the growth of bacteria. If fish is spoilt to quite and extent, bacteria increase in the muscle rapidly and spoilage is accelerated of course, but at the early stage of spoilage at least, which is now our question, it is possible that bacteria do not increase in spite of the fact that quite a large quantity of V.B.N. is existing.

Unless special consideration is given in the preparation of test sample, it would be meaningless to make freshness test by determining that fish is at the early stage of spoilage if the number of bacteria reaches $10^5$–$10^6$ in 1 g. of the muscle.

It is a question whether this experiment was carried out under the completely germ-free condition. The same thing can be said with our own experiments, too, and therefore it is possible that the muscle having no bacteria at all actually is determined as having some. But the question is whether or not bacteria increase in the muscle. Once bacteria begin to increase, they increase very rapidly, and therefore, even if some bacteria might be existing when the experiment is to be carried out, it does not matter very much.

## Conclusion

1. Under the room temperature 20–28°C and humidity 93.5–96.0%, 5 bonitoes in the original form were hung with the tails upside, and one of them was used as the sample every day for 4 days. The number of bacteria, V.B.N. and pH were determined in 3 layers of the muscle under the skin. The result of the experiment shows that the number of bacteria on the skin reaches the maximum in one or two days, and it was recognized that fish was at the early stage of spoilage by then according to V.B.N., pH and functional observation, but there was no remarkable increase in the number of bacteria in the muscle in one or two days. When 3–4 days have elapsed, we found bacteria were gradually growing.

2. Under the room temperature 18.5–27.5°C and humidity 92.5–98.0%, the number of bacteria, V.B.N. and pH in the muscle were determined every day after the lapse of 4 days with frigate mackerels and chub mackerels as the test sample.

In the middle of October another experiment was carried out with chub mackerels and yellowtails under 14.8–21.3°C room temperature. The samples

untested for the first 2 days, and observation was made on the 3rd, 4th and 5th days. In both of the experiments, the quantity of V.B.N. in the muscle has reached 50-100 mg.%, and the fishes were found spoilt, but little increase in the number of bacteria was observed.

3. From the results of the experiments, it can hardly be said that bacteria which have invaded and increased in the muscle directly act on the composition of V.B.N. in large quantity. It is considered that V.B.N. which has been composed in other body parts where bacteria increase rapidly penetrates into the muscle or enzyme composed by bacteria in these parts enters into the muscle and decomposes it. Or both of these two factors work together.

A test for freshness of fish by the measurement of bacterial number would be meaningless, unless special care and consideration are taken in preparation of the test sample, for it is possible that there might be some differences in the number of bacteria in different parts of the fish body at the early stage of spoilage.

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# ON A NEW SPECIES OF PARASITIC COPEPODS FROM *YAMAME* (SALMONOID FISH) OF JAPAN

Toshikazu Hoshina and Go Suenaga

(Received May 20, 1954)

In a considerably high percentage *yamame*, a landlocked form of *Oncorhynchus masou* (Brevoort) from the tributaries of Kiso River was found parasitized in the branchial chamber by a new species of *Salmincola* of the family Lernaeopotidae.

The authors are indebted to Mr. Soji Nakano of Research Society of Fisheries for the material on which the present report is based, and to Professor Dr. Satyû Yamaguti of Okayama University, for his aid rendered in the preparation of the manuscript.

## *Salmincola yamame* n. sp.

(Text-figs. 1–4 and Plate I, Figs. 1–8)

**Materials.**—Collected Sept. 5, 1952 by Mr. Yoshi Hagiba of Narai Fisheries Cooperative Association in Nagano Pref. from twenty one specimens of *yamame* out of seventy five captured in Suekawa, a branch stream of Kiso River, at Kaita Village, Nagano Pref..

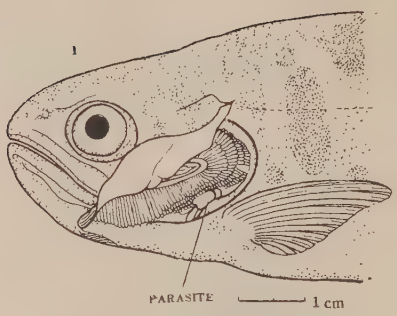
Record of collection of twenty three females from five host individuals is as follows:

| Host fish* | Nos. of parasites found | |
|---|---|---|
| | Right gill chamber | Left gill chamber |
| 1 | 4 | 4 |
| 2 | 0 | 1 |
| 3 | 4 (one female from ventral fin) | 2 |
| 4 | 4 | 1 |
| 5 | 1 | 2 |

* Body length 10.5~17.0 cm; body weight 24.5~95.6 g.

**Habitat.**—Attached to inner surface of operculum or wall of gill chamber with bulla embedded in host tissue (Text-fig. 1), or rarely on body surface at base of ventral fin.

In many cases at the point of attachment there was seen a swelling, due to hyperplasia of the epithelial tissue of the host, with polymorphic or spindle-shaped cells and some mucous cells, including numerous small lymphocytes, and generally a congestion of the blood vessels was observed in the subepithelial




Text-fig. 1. Parasite *insitu*.

tissue (Text-fig. 2).

However, no regressive pathological chages were found in the lesion. The gill filaments to which the parasite had been attached were shortened or distorted at their distal portions showing under a microscope a pronounced proliferation of epithelial cells (Text-fig. 3).

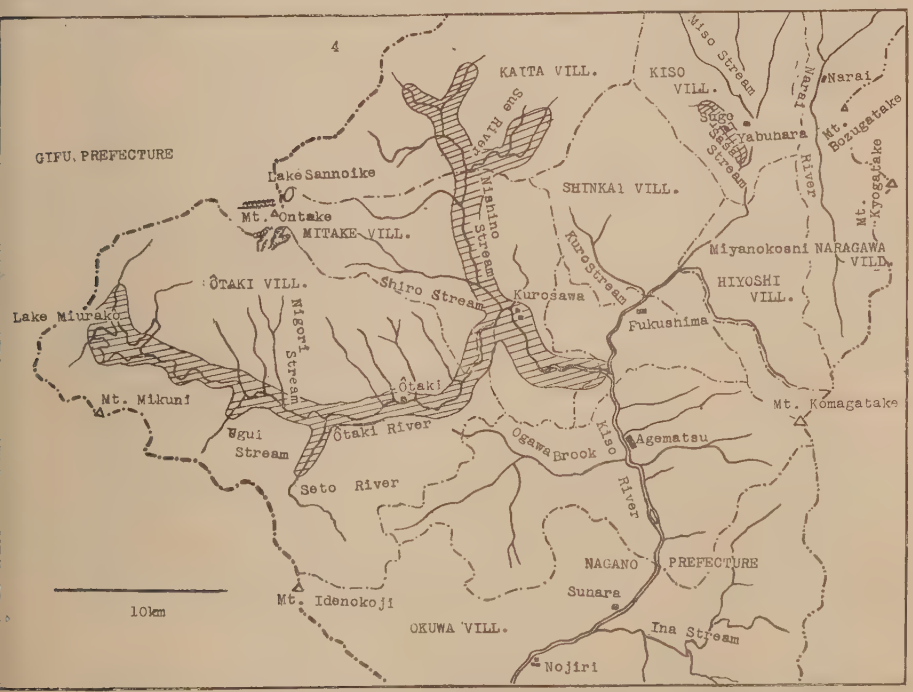
From these observations, there is no doubt that the parasite had some harmful effect upon the host fish.

**Distribution.** — The parasite has been found so far in the tributaries of Kiso River. The range of its distribution a worked out by Mr. HAGIBA is shown in the following map (Text-fig. 4).

Text-fig. 2. Crossection of infected clavicular part, stained with Delafield's haematoxylin and eosin. Bu bulla; CV congested capillary vessels; Ep proliferated epithelial tissue; Mp tip of second maxilliped; Pt petiole of bulla.

Text-fig. 3. Longitudinal section of gill filaments, stained with Mallory's stain. GF, distorted gill filaments; NGF, normal gill filaments.

**Description.**—The morphological characteristics of the parasite are as follows: Male unknown. Female.—Body plump, whitish in formalin 3.3~4.1 mm in total length. Cephalothorax without dorsal carapeace; triangular, with convex sides in dorsal view; somewhat longer than wide, 1.71~2.48 mm in length and 1.51~2.16 mm in width, at right angles to the trunk axis. Trunk 1.93~2.07 mm long by 1.93~3.11 mm broad; its anterior portion constricted and forming a short neck about 0.7 mm long. No genital or posterior process. No abdomen. Egg strings widely separated at their base, 1.91~3.45 mm long by 0.75~1.24 mm broad; eggs rounded, 0.25~0.35 mm in diameter; arranged in several longitudinal rows. First antenna 2-segmented, 0.07~0.09 mm long by 0.03~0.04 mm broad at base; distal segment with two papilliform processes and one small spine at tip.




Text-fig. 4. Distribution map of parasite. Range of distribution indicated by oblique lines.

Second antenna biramose, 0.14~0.17 mm long, basal portion very stout and 2-segmented; inner ramus 2-segmented; first segment with a nodule covered with minute papillae on distal inner side; second segment tipped with three stout spines of which the outer one is larger than the other two; outer ramus small and fringed with minute papillae at tip. Mandible with five teeth on ventral side of their distal portion.

Maxilla without palp, 0.08~0.11 mm long by 0.03~0.035 mm broad; terminating in three spines.

First maxilliped 3-segmented; second segment with a digitiform process at about middle of its inner side; terminal segment with a spine on inner side near its distal end and a claw at tip.

Second maxilliped about as long as trunk, 2.69～3.37 mm long by 0.71～1.12 m broad, somewhat curved and attached separately to petiole of bulla. Bulla mushroom shaped, 1.44～2.02 mm in diameter.

**Remarks.**—Only one species of parasitic copepods belonging to the genus *Salmincola* has been reported from Japan, viz., *S. falculata* (WILSON, 1908) WILSON, 1915, which was found in the mouth cavity of a landlocked *Oncorhynchus nerka* (WALBAUM) from Lake Penke, Hokkaido.

The present new species resembles *S. bicauliculata* (WILSON), 1908 on the one hand *S. falculata* (WILSON, 1908), on the other, but it is distinguishable from either of them by the differences in the characters of the mouth parts or the cephalothroracic appendages.

The specific name is the Japanese name for the host fish.

## Summary

1. A parasitic copepod, *Salmincola yamame* n. sp. from the branchial cavity, occasionally from the body surface of *yamame*, landlocked *Oncorhynchus masou* (BREVOORT) captured in a branch stream of Kiso River (Suekawa, Kaita Village, Nagano Pref.) on Sept. 5, 1952. is described.

2. A brief note on the pathological changes caused by the parasite in the host's tissue as well as on the distribution of the parasite is given.

## Literature

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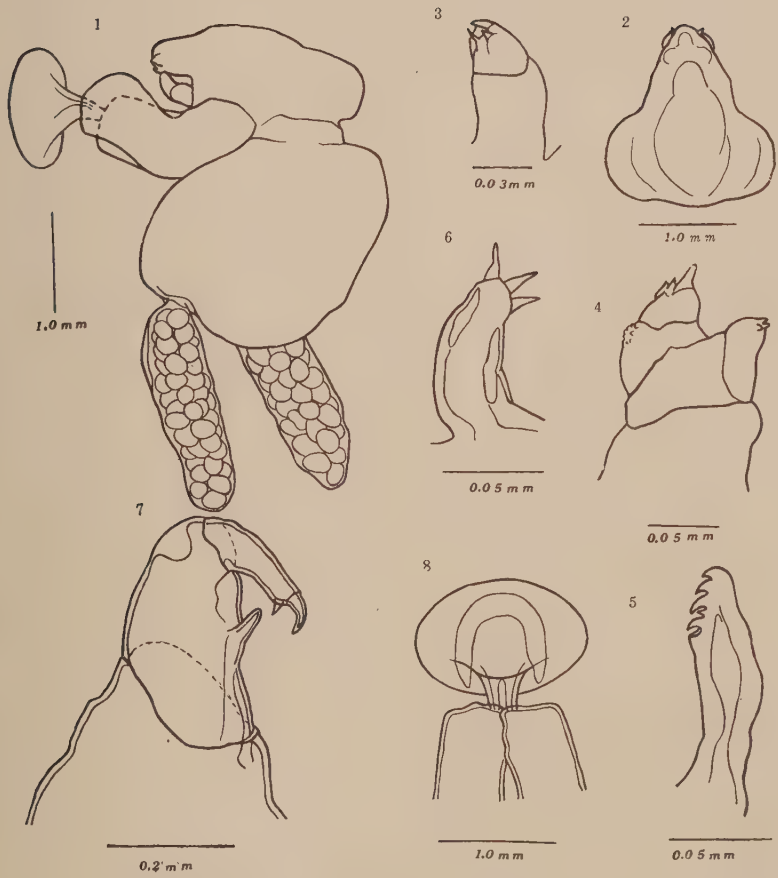


Figs. 1~8.—*Salmincola yamame*, female: Fig. 1 side view of a female; Fig. 2 dorsal view of head; Fig. 3 first antenna; Fig. 4 second antenna in lateral view; Fig. 5 mandible; Fig. 6 maxilla; Fig. 7 first maxilliped; Fig. 8 Bulla in dorsal view.

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# AN AMENDED NOTE ON ICHTHYOLOGY OF THE SURVEY OF THE MYOJIN-SHO, 1952, WITH SPECIAL REFERENCE TO A MYCTOPHID FISH, *LAMPANYCTUS (LAMPANYCTUS) PUNCTATISSIMUS* GILBERT

Kazunori TAKAGI

(Received April 1, 1954)

On the occasion of the first survey of the submarine eruption of the Myojin-sho, a rock bank occurring about 400 km southward of Tokyo, in September 1952, Prof. K. EBINA and the present writer, biological staff of the survey, happened to collect near the crater some fish: three dead of deep-sea fishes and two living fish which belong to the Plectognath fishes. It may be rather small collection, which was barely secured, when we had encountered a rather frequent eruption period. It is our regret to have no time to survey enough the area some distant from the danger. If possible, we should not be able to expect more acquisition, for the eruption first reported by a fishing boat which the bank's name owes to had took place a week before we reached the position, and since the beginning it was proved to have kept up at any rate its activity.

The results of the survey were published last year in the Journal, where EBINA and TAKAGI reported the descriptive catalogue of fishes, including also the catch get by the Bayonnaise Islands near the bank. After re-examination of the collection and data, however, we come to conclude the results must be partly amended, which relates to the fish from the bank, especially a lantern fish being out as *Macrostoma pusillum* (JOHNSON) in the said report.

The present writer must express his hearty thanks to Prof. K. MATSUBARA for his valuable suggestion and for supporting him in the course of this work. His sincere gratitude is due to Prof. I. KUBO for supervision of preparing the manuscript. Thanks are also due to Dr. T. ABE and Messrs. M. NAKAMURA and Jin HATTORI for their kind aid in various ways.

The *Macrostoma* fish of those deep-sea fishes may be subjected to some amendments, as mentioned above, of its description and figure. As far as his close investigation, the present writer reveals it is apparently *Lampanyctus (Lampanyctus) punctatissimus* GILBERT, 1913. The fish seems to have never been recorded since it was proposed new to science, except of a nominal record by KURODA (1947: 26). The sample put at our disposal is rather considerably damaged, especially on the vent, where the body is torn off to be made weak and deformed. However, it does not appear to hinder a revision to some extent, which may offer some additions to our knowledge of the species.

Measurements given below are in hundredths of standard length. Standard and total lengths are measured from the tip of snout to above $Prc_1$ and to the end of the mid-caudal rays respectively. Of the terminology and appellation are referred BOLIN, 1939, and FRASER-BRUNNER, 1949, unless others required.

The description and figure of the fish presented in the above mentioned paper by the senior author, then, may be reshaped as follows:

### *Lampanyctus* (*Lampanyctus*) *punctatissimus* GILBERT, 1913

Japanese Name: Tomi-hadaka

*Lampanyctus punctatissimus*, GILBERT, 1913, Mem. Carnegie Mus., 6 (2): 103–104, Sts. 4969, 5058 and 5064 (description only); TANAKA, 1921, [Japanese ichthyology.] vol. 1: 306 (synoptic description copied, where given first japanese name); PARR, 1928, Bull. Bingham Oceanogr. Coll., 3 (3): 88 (key); PARR, 1929, Proc. U. S. Natl. Mus., 76 (10): 23, fig. 10 (note with figure of type); KURODA, 1947, Seibutu, Suppl. 1: 26, Numazu, Suruga Bay (simply nominal record).

*Lampanyctus* (*Lampanyctus*) *punctatissimus*, FRASER-BRUNNER, 1949, Proc. Zool. Soc. London, 118 (4): 1090 (key and figure).

*Macrostoma pusillum* (part), EBINA and TAKAGI, 1953, Journ. Tokyo Univ. Fish., 40 (2): 26–27, pl. xxiii, fig. 1, Myojin-sho (description with figure).

Dorsal rays 12, anal rays 17, pectoral rays 12, pelvic rays 8, caudal rays 17+16. Scales on lateral line 34, from origin to above $Prc_4$. Gill-rakers on first arch 4+1+9. Vertebrae 14+21, counted by a ultra-soft roentogen photogram.

Head length 30.4, eye 5.2 in horizontal distance (5.2 in head), interorbital space 6.2, length of snout 5.2, length of upper and lower jaws 21.3 and 22.9 respectively; depth of body 18.6; length of caudal peduncle 20.6, its depth 9.2; distance from tip of snout: to origin of pectoral 30.1, of pelvic 41.2, of dorsal 43.8, of anal 56.6, and to last dorsal ray 57.6; length of pectoral 44.5.

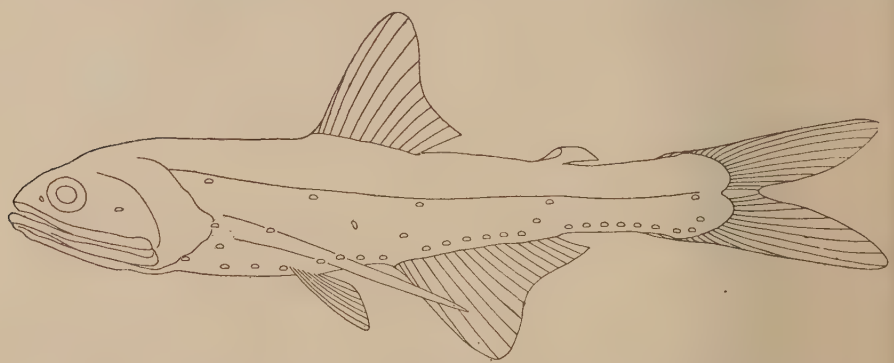

Fig. 1. Diagramatically showing *Lampanyctus* (*Lampanyctus*) *punctatissimus* GILBERT, 1913 (30.5 mm. in standard length), especially its photophore arrangement. Finrays all simplified on the figure.

Snout short, but not blunt. Eye above first third of maxillary in front of pupil; middle of maxillary under posterior border of eye. Teeth on jaws minute, in narrow band. Origin of dorsal behind base of pelvic. Anal begins under end

of dorsal base. Pectoral long, its depression notably extends to middle of anal base or to above $AOa_4$.

Photophores: One photophore on middle of cheek, on the same level of lowermost border of eye. Vn one, before center of pupil. No Ce observed on both sides. PLO under but near lateral line. $PVO_1$ somewhat above middle of pectoral base, touches distal margin of depressed operculum; $PVO_2$ below the base and behind $PVO_1$, on a line joining this and $PO_2$. PO five; $PO_4$ elevated, over space between $PO_3$ and $PO_5$, on a level with middle of pectoral base. VLO, as well as $SAO_3$, Pol and $Prc_4$, elevated to very near, but more or less under lateral line. VO four, level, none of them elevated. SAO three, well angulated, but not come to form a right angle; $SAO_1$ over interspace between $VO_2$ and $VO_3$, somewhat elevated in comparison with $SAO_2$, though a little below a line connecting VLO and $SAO_2$; $SAO_2$ midway between $VO_1$ and $SAO_3$. Pol one, very near and below lateral line, under middle of adipose-fin base. AOa seven; last AOa well elevated obliquely backward on a line joining $AOa_6$ and Pol to midway between latter two; anterior six not elevated, on the same level. AOp six, continue on Prc, holding a somewhat wider spacing between the two series. Prc four; first two level, $Prc_3$ well elevated, so lower Prc tend to conform along ventral contour of tail a waving curve with some posterior AOp; last Prc close to lateral line, above and very slightly in advance of $Prc_3$. Additionally proved some subsidiary photophores at their position, as noted by the preceding investigators.

Median luminous glands two each in front of upper and lower caudal bases; a single larger one before adipose fin along its anterior edge.

Color in formaline equally blackish brown. Fins more or less blackish brown on base, which become pale toward their extremity.

The fish drifting among more or less grained pumice was catched after our observation of the second explosion on September 23, 1952, at the position of 31°56.7′N, 139°58.4′E (cf. Niino, 1953: 11). Sex unknown.

Dimensions in mm.

| | | | |
|---|---|---|---|
| Total length | 33.8 | Length of caudal peduncle | 6.3 |
| Standard length | 30.5 | Depth of caudal peduncle | 2.8 |
| Length of head | 9.3 | Distances from tip of snout: | |
| Diameter of eye | 1.6 | to origin of pectoral | 9.2 |
| Interorbital space | 1.9 | to origin of pelvic | 12.6 |
| Length of snout | 1.6 | to origin of dorsal | 13.4 |
| Length of upper jaw | 6.5 | to origin of anal | 17.3 |
| Length of lower jaw | 7.0 | to last dorsal ray | 17.6 |
| Depth of body | 5.7 | Length of pectoral | 13.6 |

The specimen here described generally agrees well with Gilbert's *Lampanyctus punctatissimus*, and it has most of necessary points proposed by Parr, 1928, and Fraser-Brunner, 1949, excepting some probably negligible differences in our material, of which the following lines will be presented:

(1) In comparison of dimensions is easily proved a general tendency of lower value than that in the type, especially on the distance from the tip of

snout to the origins of pelvic and dorsal, and to the last dorsal ray (41.2, 43.8 and 57.6 to 46, 48 and 62 of the type respectively), except of the length of pectoral, of which are made out some words below, and the depth of caudal peduncle (9.2 to 7). The dissimilarities come probably from the difference of the size of body. The type is about two thirds of the present specimen in standard length.

(2) Pectorals are very long with measurement of 44.5, while GILBERT (1913: 103) says of them, based upon more or less mutilated specimen, "apparently not extending much if any beyond the front of anal," and their measurement from the PARR's figure of the type (1929: 23, fig. 10) is 21.7. It seems to be a notable distinction, and it may be passed over in view of the bad condition of the type specimen.

(3) The photophore of Ce is absent, probably because of the nape mostly harmed, while present in the type, according to GILBERT (1913: 103) and PARR (1928: 88; 1929: 23, fig. 10). When the organ is disregarded, the species bears close resemblance in its related group to *Lampanyctus* (*Lampanyctus*) *alatus* GOODE and BEAN, 1895 (=*Lampanyctus pseudoalatus* TAANING, 1918), as pointed out by GILBERT (1913: 103), PARR (1928: 89) and FRASER-BRUNNER (1949: 1090). The fish in question is believed to be distinguished from the latter species at least by having somewhat longer sharp snout (to rather shorter and blunt one of the latter), smaller eye (measurement of 5.2 in head, to 3.9–4.3, calculated from PARR (1929: 25), and seven AOa and one Pol (to eight AOa and one Pol, or seven AOa and two Pol, on the authority of GOODE and BEAN 1895: 79, pl. xxiv, fig. 92), PARR (1929: 26, fig. 12) and FRASER-BRUNNER (1949: 1090, figure). This notwithstanding, the photophore is not found on the figure by FRASER-BRUNNER (1949: 1090) and he does not seem to regard it with a distinct organ, or at least with an inevitable feature of the group of the fish. It is noteworthy here that, as for the other photophores, no casualties are done to all organ, except that only $AOp_2$ on the left side is lost, leaving its trace behind, even if the skin surrounding some of them, especially cheek organ and $SAO_2$ on the left and VLO on the right (Fig. 2), comes off. The question is no Ce, of all others, nor its marks remain. Besides GILBERT refers originally to their interrelationship, as shown above, but the differences pointed out by him has not any support now.

(4) Another evident differentiae may be the position of some photophores. The positions of PLO, $SAO_2$, and last AOa differ from those in the type. They have all a trend of taking upper position than the type's. FRASER-BRUNNER (1949: 1090) proposed those three points to separate the species from the said *alatus*. Nevertheless it seems to be difficult to apply them to our material, which is found to be similar to *alatus* in these points.

(5) Luminous scales before the lower caudal lobe is two on our specimen, while three on the GILBERT's.

Also the locality of *punctatissimus* may be entitled to discuss. GILBERT describes the species basing on material from the Suruga Bay and his station of 33°23′40″N, 135°33′E (approximately off southward of Wakayama Pref., Japan). Recently KURODA (1947: 26) records, as mentioned above, some specimens washed

ashōre on both coasts of Togo and Shige, Numazu, confronting the Suruga Bay, and he (1950: 33; 1951: 319) finds out the species comes exclusively from these localities, and here is added to the record of new locality. After all there is apparently no need for any change in the fact that it may be regarded after TANAKA (1932: 18) as a fish of the "Southern Japan area."

Additionally some words will be said herewith.

The injury to the vent does not make us ascertain sufficiently the arrangement of some PO.

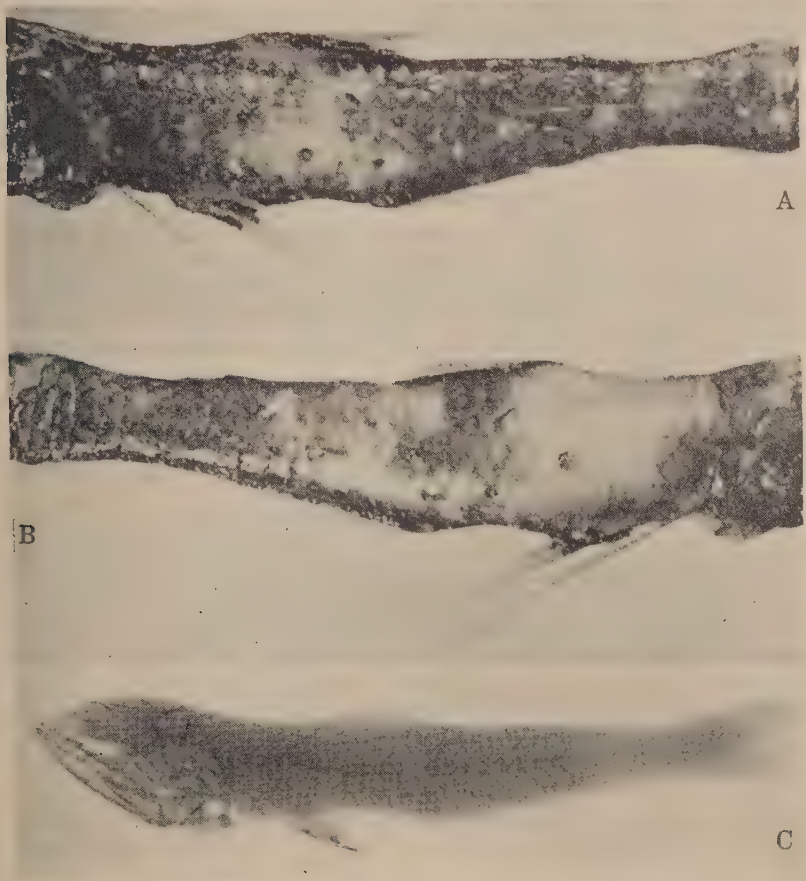


Fig. 2. *Lampanyctus* (*Lampanyctus*) *punctatissimus* GILBERT, 1913 (30.5 mm. in standard length). Lateral view of left (A) and right (B) sides, and X-radiograph (C) by the "Softex," ultra-soft roentogen ejector.

GILBERT (1913: 103) describes SAO as "forming a right angle." As far as we depend upon the PARR's figure for the detail of the type, it is not the case, which seems to be the same as the present writer notes here of them.

It is clear now that the present specimen is discriminated from *Lampanyctus* (*Lampanyctus*) *pusillus* (JOHNSON, 1890) having sufficiently such points cited by FRASER-BRUNNER (1949: 1089) in his key as "VLO midway between lateral line and base of pelvic fin, no luminous gland at adipose fin," and "AOa evenly arched."

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# ON *PLATYMAJA ALCOCKI* RATHBUN (BRACHYURA, OXYRHYNCHA) OBTAINED FROM OFF AMATSU, PROVINCE BŌSHŪ, JAPAN*

Jirō SENŌ and Kenjirō KONNO

(Received May 15, 1954)

One specimen of spider crab was collected on April 29, 1953, by the junior author at the coast of Miiri in Amatsu, a western town of Kominato. It was obtained by a "Naname-ami", a kind of bottom gill-net, used for the catch of flatfish (*Paralichthys olivaceus* (T. & S.)), at a depth of about 260~270 metres (Text-fig. 1).

Dr. T. SAKAI of Yokohama National University, to whom the photograph of this specimen and the materials of reference were sent for identification, informed us that it might belong to *Platymaja wyville-thomsoni* MIERS and we shortly reported it on April 24, 1954, at the 6th Grand Meeting in Kantō Local Branch of the Zoological Society of Japan.

The genus, *Platymaja*, was established by MIERS[5], belonging systematically to the subfamily, Inachinae, in Majidae, and its samples were gathered by several authors in foreign waters and by our seniors from the localities mentioned below in Japanese waters (Table 1, Text-fig. 1).

Table 1. The habitats and notes of *Platymaja w.-t.* MIERS and *P. alcocki* RATHBUN in Japanese waters.

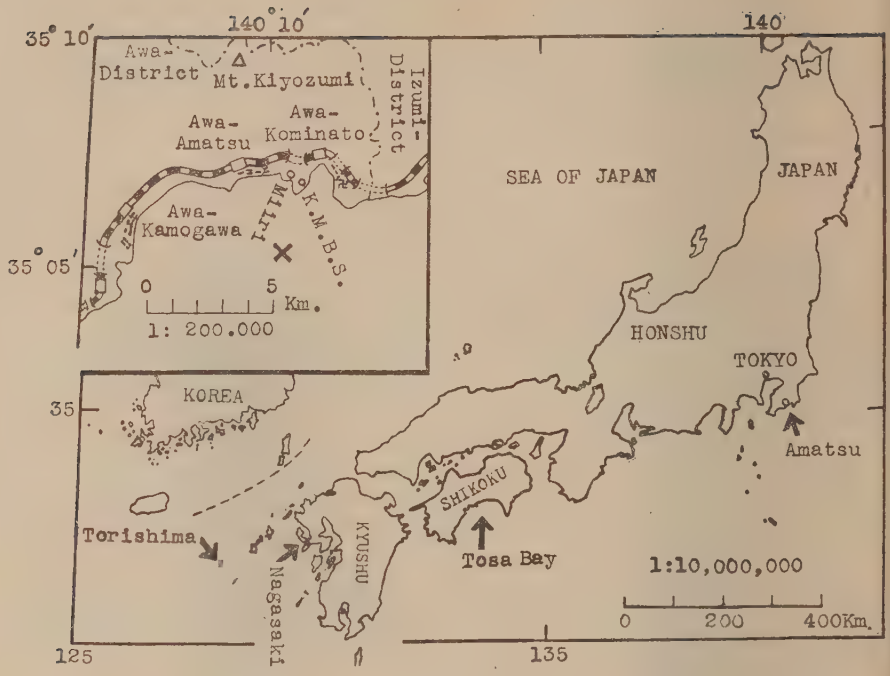
| | *Platymaja w.-t.* MIERS | | | | *P. alcocki* R. |
|---|---|---|---|---|---|
| Localities | Tori-shima | off Tosa | Tosa Bay | Nagasaki | off Amatsu |
| Depth (m.) | 150 | unknown | 150~400 | unknown | 260~270 |
| Specimens | 1♂ | 1♂ | 2♀ | 1♀ | 1♂ |
| Carapace (mm.) (l.)×(br.) | 27.2*×33.0 | —— | 27.0*(32.5)** ×32.2 | —— | 23.8*(28.9)** ×29.2 |
| Authors | MIYAKE 6) | MIYAKE 6) | SAKAI 9) | SAKAI 9) | SENŌ & KONNO |

*, length of carapace excluding rostrum; **, length of carapace including rostrum.

After the reexamination of the specimen for the publication of this paper, Dr. SAKAI and the present authors came to the conclusion that it might belong to *Platymaja alcocki* RATHBUN[7] for want of supra-orbital spine at the posterior end of the preorbital lobe against the true *Platymaja wyville-thomsoni* which has the spine mentioned above. While ALCOCK[1], CHUN[2] and DOFLEIN[3] described the former type, MIERS[5], RATHBUN[8], IHLE and IHLE-LANDENBERG[4], MIYAKE[6] and SAKAI[9] reported on the latter form.

In regard to the Japanese specimens hitherto obtained, the existence of the supra-orbital spine is reported by MIYAKE but not informed by SAKAI. The

* Contributions from the Zoological Laboratory, Tōkyō University of Fisheries.




Text-fig. 1. Geographical distribution of *Platymaja wyville-thomsoni* Miers and *P. alcocki* Rathbun in Japanese waters. K. M. B. S.=Kominato Marine Biological Station of Tōkyō University of Fisheries.

latter author is of opinion that *P. alcocki* may be a local variety of *P. wyville-thomsoni*, and that his specimen, reported as *P. wyville-thomsoni*, may attribute to *P. alcocki* at present. Similar to the opinion of Rathbun[7][8] who distinguished those two forms into two species and of Ihle and Ihle-Landenberg[4] who recognized the other form as a subspecies of the typical form, we have considered our specimen as *Platymaja alcocki*.

Table 2. Measurements of the ambulatory legs of male *Platymaja alcocki* Rathbun from off Amatsu, Province Bōshū.

| Ambulatory leg | (1): Length of amb. leg (mm.) | | (1)/carapace* | | (2): Length of merus | | (2)/carapace* | |
|---|---|---|---|---|---|---|---|---|
| | left | right | left | right | left | right | left | right |
| 1st | 130.0 | missing | 5.5 | — | 50.0 | — | 2.1 | — |
| 2nd | 144.8 | 142.6 | 6.1 | 5.9 | 51.0 | 50.3 | 2.1 | 2.1 |
| 3rd | missing | 120.5+α | — | $\frac{120.5+\alpha}{23.8*}$ | — | 46.8 | — | 2.0 |
| 4th | missing | 123.8 | — | 5.2 | — | 44.0 | — | 1.8 |

*, length of carapace excluding rostrum ; α, length of the broken portion of dactylus.

The features of carapace and ambulatory legs in our specimen generally agree with those described by the previous authors, MIERS[5], RATHBUN[8], IHLE and IHLE-LANDENBERG[4] and MIYAKE[6], and our male specimen coincides with DOFLEIN's and SAKAI's figure in having no supra- orbital spine, and with DOFLEIN's fifth stage (male) regarding the dimensions of the carapace and the characters of the abdominal segments.

The chelipeds of our male specimen are nearly equal; the left being 46.5 mm. and the right 46.2 mm. in length. Among the ambulatory legs the first (missing the right leg) is more spinous, especially on propodus, than following pairs with numerous long spines on the interior margin and spinules on the exterior border. Measurements of the ambulatory legs and spinous and hairy conditions on the cheliped and the ambulatory legs of the present material are tabulated as follows (Tables 2 and 3).

Table 3. Spinous and hairy conditions on the cheliped and the ambulatory legs of male *Platymaja alcocki* RATHBUN.

| | | Merus | | Carpus | |
|---|---|---|---|---|---|
| | | Anterior border | Posterior border | (1): Interior margin | (2): Exterior margin |
| Cheliped | | p′(+) | s″ | short p′(+) | |
| | | P(+) | — | | |
| Ambulatory legs | 1st | p(+) — | p′(+) | p′(+) | p′(+) |
| | 2nd | — p′(+) | p′(1) | p′(1~2) | p′(1) |
| | 3rd | — p′(+) | p′(1) | — | p′(1) |
| | 4th | — — | p′(1) | — | p′(1) |

| | | Propodus | | Dactylus | |
|---|---|---|---|---|---|
| | | (1) | (2) | (1) | (2) |
| Cheliped | | fairly broad, carinate dorsally, p′(+) | s″ | immovable finger: denticulated on its inner margin | |
| | | P(+) P(+)** | — | p′(+) | s″ |
| Ambulatory legs | 1st | P(+) P(+) — — | p′(+) — | P(+) p(+) — | p′(+) — |
| | 2nd | — p(+) p′(+) s | p′(+) s′ | — — s* | p′(+) s′ |
| | 3rd | — — p′(2) s | p′(1) s′ | — — s* | — s′ |
| | 4th | — — — s | p′(1) s′ | — — s* | — s′ |

p, spines; p′, spinules; P, prominent spines; s, tuft of setae; s′, loose linear setae; s″, thinly setose; s*, tuft of setae only at the proximal region; +, above three in number; **, medio-superior surface.

It is recognizable the existence of two pairs of lobes at the postero-lateral region of the sternum in ventral view of the specimen; the former pair armed with one spinule lies between the third and fourth legs on either side of the carapace and the latter one, armed with four spinules on the left and with three on the right side, situates between the fourth and fifth legs.

Colour of our specimen before conservation is probably similar to that of female and of male specimen of *Platymaja w.-t.* in the plate with a heliotype indicated by Sakai[9] and Doflein[3], respectively.

Genus *Platymaja* ranges widely in Indo-Pacific regions; *P. wyville-thomsoni* has been obtained from Admiralty Is.[5] (225 m. in depth, 1♀), Great Australian Bight[8] (120～375 m., 2♂, 5♀), between Bali and Kangeang[4] (289 m., 1♂), north of Batan Is.[4] (397 m., 1♂), Torishima[6], Nagasaki[9] and Tosa Bay,[6][9] and *P. alcocki* from Andaman Sea[1] (238～748 m.), near Nicobar Is.[3], west of Sumatra[3], near Dar-es-Salaam[3] (East Africa) and Zanzibar-Canal[3] (East Africa). Off Amatsu is recognized at present as the northern limit of distribution of this species.

The authors wish to return herewith our hearty thanks to Dr. T. Sakai for his kind identification, helpful criticism, generous support in referring to the literatures and troublesome revision of the manuscript. Thanks are also due to Prof. Y. Matsue of Tōkyō University for offering us facilities to read Doflein's literature.

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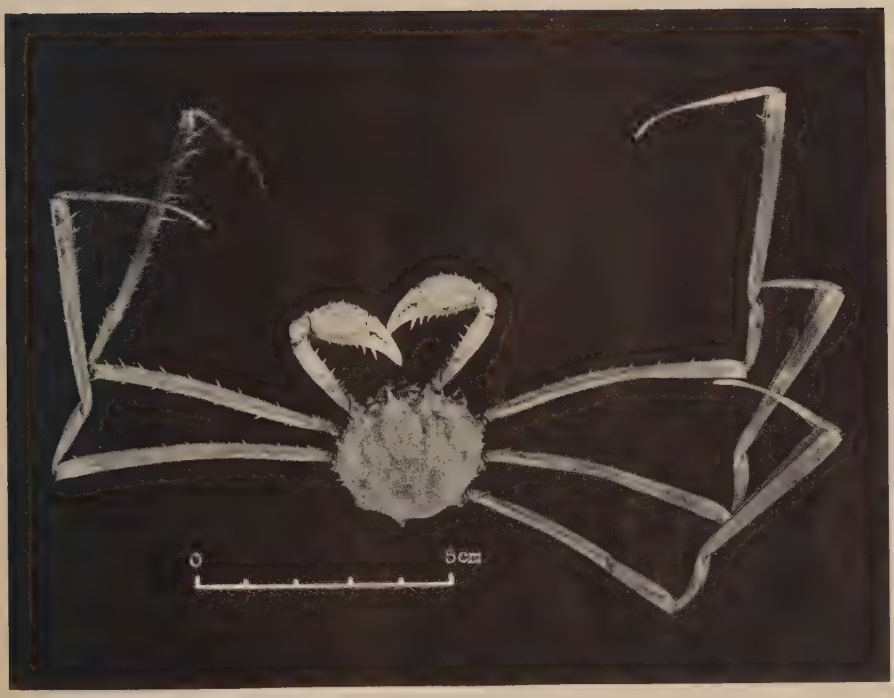


*Platymaja alcocki* RATHBUN. ♂, from off Amatsu, Province Bōshū, Japan.

Journal of the Tokyo University of Fisheries, Vol. 41, No. 1, 1954

# SYSTEMATIC STUDIES ON THE JAPANESE MACRUROUS DECAPOD CRUSTACEA

## 2. On two Penaeids, *Metapenaeus affinis* (H. MILNE-EDWARDS) and *M. burkenroadi*, nom. nov., erected on the Japanese Form known as *M. affinis*.

Itsuo KUBO

(Received March 15, 1954)

A comparative study has been done dealing with many specimens of *Metapenaeus affinis* (H. MILNE-EDWARDS) trawled in October, 1953, from creeks in the vicinity of Karachi, India, and a lot of specimens of the Japanese form known as *Metapenaeus affinis* since Kishinouye (1900) taken from various localities of Japan. It is revealed as the result of the present scrutiny that the Japanese form differs so considerably from the Indian form as to establish a new species on the former form.

In this article, some descriptions as to the Indian form, supplementing those done by the previous investigators are given in addition to the description of the new species proposed here.

The writer is grateful, before proceeding any further, to Mr. Ei-ichi TAKEUCHI, by whom the Indian material is offered. Sincere appreciation is extended to Dr. Tadao UMESAO in the matter of important literature, and to Mr. Jin HATTORI for his effort afforded in the reproduction of literature. Finally hearty thanks are due to the Ministry of Education as the expense of the present study is partly supported by the Grant in Aid for Fundamental Scientific Research of the Ministry.

### *Metapenaeus affinis* (H. MILNE-EDWARDS)

(Fig. 1, E–L, and Fig. 2, A–G)

*Metapenaeus affinis*, ALCOCK, 1906, pp. 20-21, Pl. 3, figs. 8, 8a, b.
*Metapenaeus affinis*, BURKENROAD, 1934, pp. 29-32.
*Penaeopsis affinis*, KEMP, 1915, p. 321; De MAN, 1924, pp. 4-5, figs. 2, 2a.
Not *Metapenaeus affinis*, MAKI & TSUCHIYA, 1923, pp. 38-39, Pl. 2, fig. 3; KUBO, 1949, pp. 84-85, 121, 340-344.
Not *Penaeus, affinis*, KISHINOUYE, 1900, pp. 16-18, 20-21 (in Japanese), Pl. 4, fig. 1, Pl. 7, figs. 5, 5A-5C.
Not *Penaeopsis affinis*, De MAN, 1911, pp. 57-58, Pl. 6, fig. 15a, b; BALSS, 1914, p. 7; 1924, p. 44; NAKAZAWA, 1915, pp. 27-28, 34, figs. 1-3; YOKOYA, 1941, p. 53, Pl. 1, fig. 5.
Not *Parapenaeus affinis*, RATHBUN, 1902, p. 38.

Petasma of adult form Y-shaped in general outline, with a pair of distal processes, about thrice as long as wide measured at middle and along median

line from anterior end of the structure to tip of posterior projections; shoulder rather produced; dorsal lobes somewhat dilated sidewise near middle; distal process rather short, about one-sixth the length of the organ (excluding posterior projections) on which it lies; made up of hard horn-like protrusion and rather

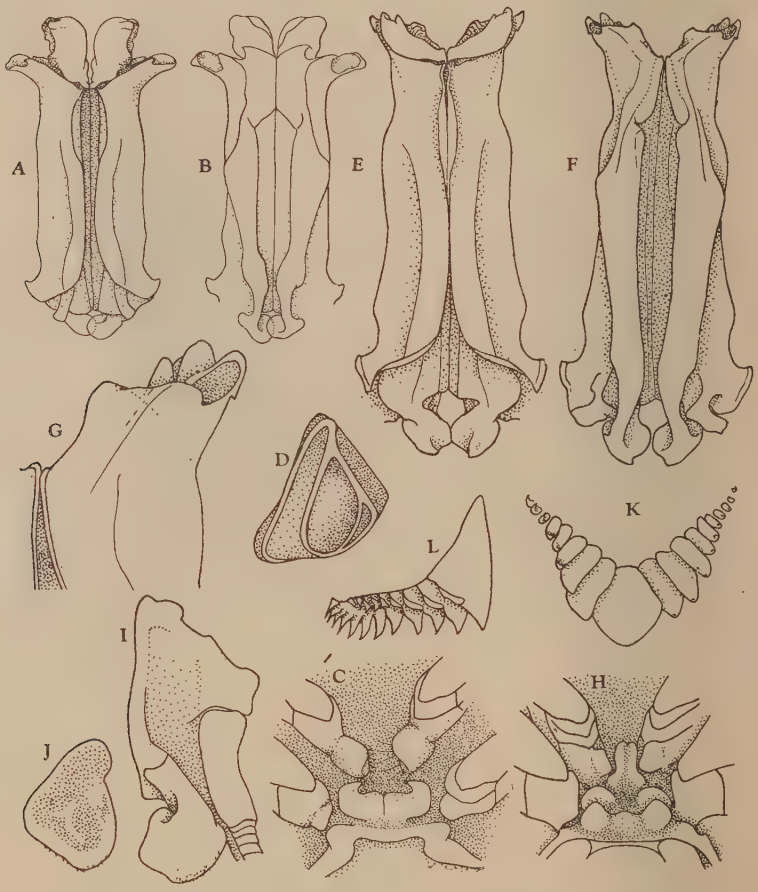


Fig. 1. Copulatory organs and others of *Metapenaeus burkenroadi*, nom. nov. (*A-D*) and *M. affinis* (H. MILNE-EDWARDS) (*E-L*). *A*, ventral view of petasma of a male, 67.5 mm long, ×6; *B*, dorsal view of the same organ; *C*, thelycum of a female, 88 mm long, ×3; *D*, apical area of appendix masculina of a male, 71.5 mm long, ×18.5; *E*, ventral aspect of petasma of a male, 97 mm long, ×5; *F*, dorsal aspect of the same structure; *G*, distal part of the same petasma, ×15; *H*, thelycum of a female, 89 mm long, ×3, *I*, appendix masculina of a male, 97 mm long, ×9; *J*, apical area of the same organ, ×13.5; *K*, ventral aspect of the teeth of urocardiac ossicle, ×26; *L*, lateral teeth of cardiac chamber of stomach, ×15.

soft petaloid lobe which arises from disto-median edge of dorsal lobe of petasma and overlaps on ventral surface of the horn-like protrusion as it turns ventrad; hard horn-like protrusion pointed at tip, provided on posterior margin near tip with a minute spine directed backwards (Fig. 1. *E*~*G*).

In young form, 48.6 mm long in abdomen measured from anterior margin of pleuron of the first abdominal segment to tip of telson, right and left pieces of petasma are not yet conjoined each other, but the minute spine of the distal horn-like protrusion is found already to exist in vestigial condition on outer edge near tip of the protrusion (Fig. 2, *B*). Disto-median projection of dorsal lobe simply swollen (Fig. 2. *B*), A deltoid membranous area is found lying on outer side between disto-lateral projection of dorsal lobe and that of ventral one as shown in the Fig. 2, *D*.

Thelycum well agrees to the descriptions and figures given by Alcock (1906) and De Man (1924) bearing two pairs of lobe-like upheavals on the last thoracic sternum and a tongue-like median protuberunce arising from a position a little posterior to the bases of the fourth thoracic legs. Median protuberance ended into two lobules with rounded apex (Fig. 1, *H*).

Appendix musculina fist-like, subtriangular in outline of apex, furnished with rather sparsely set short setae on distomedian surface (Fig. 1, *I*~*J*). The structure of the young form given already delineated in the Fig. 2, *E*–*G*.

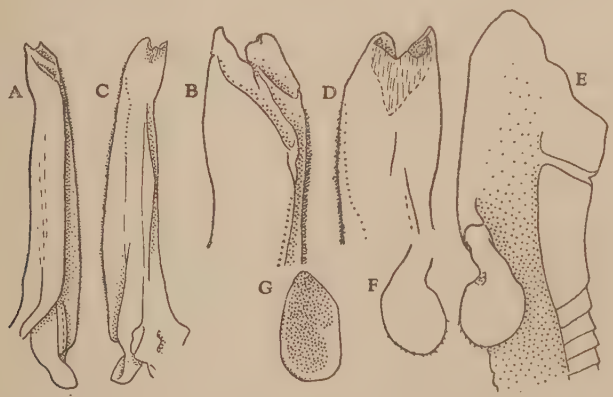


Fig. 2. Petasma (*A*-*D*) and appendix masculina (*E*-*G*) of a young male of *M. affinis* (H. Milne-Edwards) taken from the neighborhood of Karachi, India. *A*, ventral aspect, ×10.8; *B*, ventral view of distal part, ×31.2; *C*, dorsal view, ×10.8; *D*, dorsal one of distal portion, ×31.2; *E*, anterior view, ×22.2; *F*, posterior view, ×22.2; *G*, appical area, ×31.2.

Cardiac plate provided with teeth arranged in two rows (Fig. 1, *L*) as is the case with *M. joyneri*, *M. monoceros*, and others of the genus, *Metapenaeus* (Kubo, 1949, p. 173, fig. 81, *E*–*M*). Urocardiac ossicle armed with 8–10 pointed teeth on each distolateral margin and a large median tooth rounded on apex; teeth of distolateral margin become gradually larger backwards in size (Fig. 1, *K*).

The description given above is based on 2 males, 96.5 and 110.0 mm long without rostrum (30.0 and 30.7 mm in carapecial length) and 5 females ranging 80–100 mm in body-length, 25–28 mm in carapace-length fished from the Indian locality described already. Besides these, a young male, badly mutilated missing cephalothorax is also examined. It was taken from the same locality. The length measures a length of 48.6 mm in pleon as written already.

### *Metapenaeus burkenroadi*, nom. nov.

(Japanese name: Moebi)

*Metapenaeus affinis*, MAKI and TSUCHIYA, 1923, pp. 38-39, Pl. 2, fig. 3; KUBO, 1949, pp. 84, 85, 121, 340-344, Figs. 1, E; 4, D; 7, P; 22, C; 31, A & B; 40, A-E; 47, C; 52, A-C; 62, C & C'; 68, H; 74, F & L; 81, F; 124; 125, A-D.

*Penaeus affinis*, KISHINOUYE, 1900, pp. 16-18, 20-21 (in Japanese), Pl. 4, fig. 1, Pl. 7, figs. 5, 5A-5C.

*Penaeopsis affinis*, De MAN, 1911, pp. 57-58, Pl. 6, figs. 15a-b; BALSS, 1914, p. 7; 1924, p. 44; NAKAZAWA, 1915, pp. 27-28, 34, figs. 1-3; HIRUMA, 1925, pp. 423-424, fig. 5; OSADA, TANIZAKI, and NAKAZAWA, 1931, p. 6, Pl. 3, Middle, Right; YOKOYA, 1951, p. 53, Pl. 1, fig. 5, OSHIMA & YASUDA, 1942, pp. 135-146.

*Parapenaeus affinis*, RATHBUN, 1902, p. 38.

Of this species, KUBO (1949) has made an extensive description. Since there is no need to add some supplements to his description. Therefore only some mentions of the differences between the present species and *Metapenaeus affinis* (H. MILNE-EDWARDS), with which the present species, *Metapenaeus burkenroadi* has been confounded since KISHINOUYE (1900), may be given in the following lines.

Chief differences are found to exist on copulatory organs, coxal plates of the fourth pereiopods, and appendix masculina of the second pleopod. The petasma of *M. burkenroadi* is cross-shaped in general feature having a pair of thumb-like projections on distal median border of the dorsal lobes (Fig. 1, *A, B*), while that of *M. affinis* is Y-shaped with a pair of petaloid lobes on the distomedian edge of the dorsal lobes (Fig. 1, *E, F*). The thelycum consists of a pair of elevations, ox-horn-shaped in outline and flattish on ventral surface in *M. burkenroadi* (Fig. 1, *C*). But that of *M. affinis* is made up of two pairs of rather thick lobes on the last thoracic sternum and a tongue-like median process arising from a position near anterior boundary of the eighth thoracic segment (Fig. 1, *H*). The coxal plates of the fourth pereiopods of the present species are considerably larger than those of *M. affinis* as shown in the (Fig. 1, *C. H*). The appendix masculina has stripes of hard chitinous structure on its apical surface in *M. burkenroadi* (Fig. 1, *D*), while those are absent in *M. affinis* (Fig. 1, *J*).

Finally the facts that are given in the following lines, should be noted herewith. De MAN (1911, pp. 57–58) has noticed that the petasma of the specimens taken from Java, Lombok, and others differs from that figured by ALCOCK (1906), and well resembles KISHINOUYE's figure of the organ. But he has ascribed the

difference to that due to age. Afterwards Burkenroad (1934, p. 32) mentions as follows:—"Kishinouye's figure of this structure (petasma) in *M. affinis* differs so considerably from the figures by De Man, 1924, and Alcock, 1906, as to make doubtful a reference merely to age differences". This is the first to be considered that the form recorded under the name of *M. affinis* by Alcock (loc. cit.) and De Man (loc. cit.) and the form known from Japan under the same specific name are not conspecific. Wherefore the specific name of the species newly proposed is given in honour of Martin D. Burkenroad.

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Journal of the Tokyo University of Fisheries, Vol. 41, No. 1, 1954

# SYSTEMATIC STUDIES ON THE JAPANESE MACRUROUS DECAPOD CRUSTACEA

## 3. On the Palinurid lobsters

Itsuo Kubo

(Received March 15, 1954)

After making possible investigations in regard to the Japanese Palinurid crayfishes or spiny lobsters, the present author has got some advanced knowledges for the taxonomy, fauna, geographical distribution, and morphological matters of this animal. Those may be mentioned briefly under such three, A–C, sections with headings given below.

A. Some notes on the fauna of the Japanese *Panulirus*.
B. Key to the species found in Japan.
C. List of the species with synonym and some descriptions of the matters new to science.

The present author takes this opportunity of expressing his hearty thanks to Messrs. Masaharu Igarashi, Tatsuyoshi Masuda, Osamu Umebayashi and Dr. Takashi Ino, for their kindness offering valuable specimens, by which the present study is embodied. Acknowledgement is made to Mr. Hisatoshi Marukawa for his valuable suggestions of the geographical distribution of the Japan Sea coast of *Panulirus japonicus*. Thanks are also due to Mr. Jin Hattori for his favour in preparation of photographs. The expense of this study was defrayed by the Grant in Aid for Fundamental Scientific Research of the Ministry of Education, to which the author offers his cordial thanks.

### (A) Some notes on the fauna of the Japanese *Panulirus*

From Japan, five species have been known, namely, *Panulirus japonicus* (V. Siebold), *P. versicolor* (Latreille), *P. dasypus* (H. Milne-Edwards), *P. polyphagus* (Herbst), and *P. homarus* (Linnaeus)=*P. burgeri* (De Haan). Recently the present suthor has examined two other forms taken from Japan, which may be referred to *P. longipes* (A. Milne-Edwards) and *P. penicillatus* (Olivier) as given later. Consequently the Japanese fauna of this animal becomes to be composed of seven species given above. Of these seven ones, *P. japonicus* commonly occurs southwards from about 35.5°N and 34.5°N on the Pacific and on the Japan Sea coasts respectively. But it rarely appears northwards to about 38.5°N on the Pacific coast. It may be said that this animal hardly inhabits the Japan Sea coast of the main Island of Japan. The animal, however, very rarely may be seen on the coast in quetion northwards to about 37°N, as we have a record of capture of this species from Nanao Bay, which is lying on a position approximately 37°10′N, 137°E (Tokuhisa, 1914). *P. versicolor* seems to occur

rather rarely, probably on the Pacific coast only. Especially the occurrence of adult form of this species from main Islands of Japan seems to be ascribed to very rare fact. Within the limit of the writer's knowledge, only a record of collection of the adult form is present (Maeda, 1940). The rest appears to be rare, According to Holthuis (1946), *P. dasypus* has only two records known from Japan. A record has been made by Doflein (1900), detailed locality unknown, and the other by Pesta (1915), locality Yokohama. On *P. homarus*, also two records have been done by De Haan (1841) and Doflein (1906). De Haan's locality is unknown, Doflein's one is Sagami Bay. *P. polyphagus* has only a record collected by Doflein (1900) from Japan, locality unknown. It may be noted herewith that no record of collection from Japan has been made since the records given above with regard to these three species. *P. longipes* secured from Kominato fish market, Chiba Prefecture on August 19, 1952. This is the first record of collection of this species from Japan. *P. penicillatus* also firstly taken from Habu, Ōshima, about 100 Km southwards of Tokyo on September 26, 1953. This species has a record collected from Fusan (or Pusan), Korea by Pesta (op. cit.), but it has not been caught from Japanese waters before the capture given above.

## (B) Key to the species found in Japan

The seven species known from Japan may be assorted into three groups, and those included in each group are arranged genealogically basing on the ideas given in the following lines. The presence of the transverse furrow of the abdominal terga, and the absence of the exopodite or multiarticulated flagellum of the exopodite of the third maxilliped, as well as the flagellum of the exopodite of the second maxilliped are apparently positive specialization. In the meanwhile, the absence and the interruption of the transverse furrow may be interpreted as primitive features on the basis of the following facts, which were revealed by Okada and Kubo (1950). In *P. japonicus*, the transverse furrow of the pleon is not found to exist in the puerulus stage. But the Furrow becomes to be present with proceeding of the growth. It firstly appears in interrupted condition on the terga from the second to the fourth or sometimes to the fifth abdominal segments of the young smaller than 32.2 mm in body-length, and afterwards it becomes entire with advance of growth. It is generally known that the presence of the exopodite of the maxillipeds is recognized as a primitive trait. Hence the key is as follows:—

$a_1$ Abdominal terga transversely furrowed
  $b_1$ Transverse furrow of abdominal terga entire
    $c_1$ Transverse furrow of abdominal terga with crenulate edge; antennular tergum afforded with 2 pairs of large spines; exopodite of third maxilliped absent..... *P. homarus* (Linnaeus)=*P. burgeri* (De Haan).
    $c_2$ Transverse furrow of abdominal terga with straight edge; exopodite of third maxilliped present
      $d_1$ Antennular tergum carries 2 pairs of large spines, the lateral of which

are coalested at base; exopodite of third maxilliped without flagellum.. ..... *P. penicillatus* (Olivier).

$d_2$ Antennular tergum has a pair of large spines; exopodite of third maxilliped with multiarticulated flagellum

$e_1$ Antennal segment, to which antennae attach, carries on dorsal surface 2 principal spines; the area posterior to these 2 principal spines is either without or with some scattered spinules forming no set pattern. Abdomen usually not punctate, sometimes rather punctate. Ratio of B/A (see p. 98) runs 0.73–0.86 in adult larger than 112 mm in body-length (41 mm in carapace-length)..... ..... *P. japonicus* (V. Siebold).

$e_2$ Antennal segment, from which antennae sprout, provided on dorsal surface with 2 main spines and 3 or 4 (Sheard, 1949) pairs of spinules. These spinules are set immediately behind the 2 main spines in two rows of 3 or 4. Abdomen punctate. Ratio of B/A 0.93 .... ..... *P. longipes* (A. Milne-Edwards).

$b_2$ Transverse furrow of abdominal terga interrupted on median line; provided with crenulate edge; exopodite of third maxilliped absent ..... ..... *P. dasypus* (H. Milne-Edwards).

$a_2$ Abdominal terga not transversely furrowd

$f_1$ Antennular tergum armed with a pair of large spines; exopodite of second maxilliped bears multiarticulated flagellum..... *P. polyphagus* (Herbst).

$f_2$ Antennular tergum has two pairs of large spines; exopodite of second maxilliped has no flagellum; exopodite of third maxilliped absent or vestigial, usually absent .....*P. vercicolor* (Latreille).

## (C) List of species with synonym and some descriptions

### (1) *Panulirus japonicus* (V. Siebold)

Japanese name: Ise-ebi)
(Text-Fig. 1)

*Palinurus japonicus*, V. Siebold, 1824, p. 15; De Haan, 1841, p. 158, Pls. 41–42.
*Senex japonicus*, Ortmann, 1891, p. 26; Bouvier, 1899, p. 173.
*Puer pellucidus*, Ortmann, 1891, p. 37, Pl. 1, fig. 3.
*Panulirus japonicus*, Doflein, 1900, p. 129; Rathbun, 1902, p. 37, and 1906, p. 897, Pl. 5; Gruvel, 1911, p. 28, text-fig. 11, Pl. 5, fig. 1; Balss, 1914, p. 77; De Man, 1916, p. 44; Nakazawa, 1917, p. 259, Pl.; Parisi, 1917, p. 8; Maki and Tsuchiya, 1923, p. 79, Pl. 7, fig. 1; Kubo, 1938, p. 101–106, text-figs. 1–4, Pl. 1; Yoshida, 1941, p. 31, Pl. 8, fig. 1; Holthuis, 1946, pp. 123–125, Pl. 11, fig. n (ubi synon); Barnard, 1950, pp. 550–551, fig. 102, f.

Some descriptions may be given on spinulation of antennal segment and epistome, ratio of B/A (see below) of eye, colouration, and sex recognition of young form.

Antennal segment, which bears antennae, armed on dorsal surface with two principal spines near anterior border and 3-5 spinules set in a raw near

frontal edge. The area posterior to the principal spines has no spinules in most cases, but sometimes possesses some scattered spinules.

Epistome is armed with many distolateral spinules besides a distomedian and 2 distolateral spines. Distolateral spinules are 2–4 (mostly 3) in number on each side.

Ocular segment grows exponentially in length relative to carapace-length (Fig. 3, *A*). Corneal diameter measured from anterior border to the posterior one also increases exponentially, though there is some extent of variation (Fig. 3, *B*). Ratio of B/A ranges from 0.73 to 0.86 in adult larger than 112 mm in body-length (41 mm in carapecial length), *A* is the length of ocular joint, *B* the corneal diameter measured by the same method noted above. This ratio is likely to show considerable variation, especially in younger specimens (Fig. 3, *C*).

Colouration: plainly redish brown in most cases, rather frequently more or less greenish or redish. Sometimes punctate with small whitish or yellowish spots on body. This spots are similar to those of *Panulirus longipes* in general feature, but less in number. In the present investigation, the writer has exa-

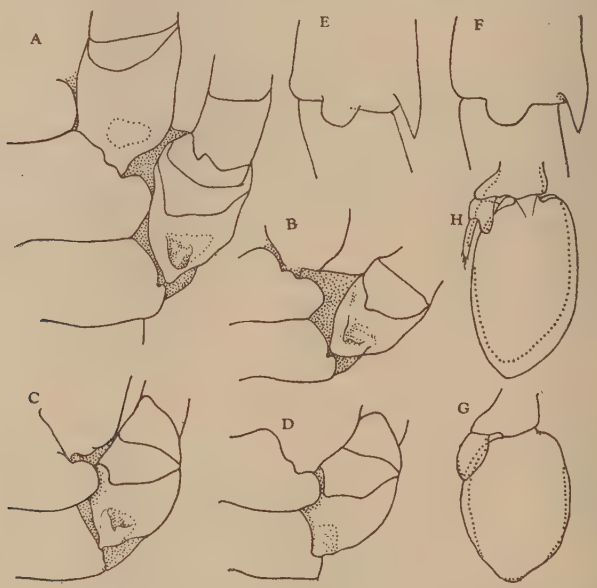


Fig. 1. *Panulirus japonicus* (V. SIEBOLD). *A*, ventral aspect of basal parts of fifth leg, especially showing sexual aperture of a male, 49.4 mm in body-length, 12.9 mm in carapacial length, ×9; *B*, the same as in *A*, male, 66.1 mm long, 21.8 mm in c. l., ×3; *C*, the same as in *A*, male, 70.5 mm long (23.1 mm in c. l.), ×3; *D*, the same as in *A*, female, 71.2 mm long, 23.2 mm in c. l., ×3; *E*, showing propodal spine of fifth leg of a male, 70.5 mm long, 23.1 mm in c. l., ×13.5; *F*, the same as in *E*, female, 71.2 mm long, 23.2 mm in c. l., ×13.5; *G*, second pleopod (posterior view) of a female, 71.2 mm long, and a male, 70.5 mm long (broken line), ×3; *H*, third pleopod, the same as in *G*, ×3. All figures are based on specimens obtained from Kominato, Chiba Prefecture.

mined several specimens furnished with such spots on body and blotches on pereiopods.

Sex recognition: in adult form, sex recognition of this animal is easy on basis of well developed primary and secondary sexual characters. But in young form, it is no easy task as the sexual dimorphism is not yet well defined. So far as the present investigation goes, the feature of external opening of sexual organs seems to afford the best clue for sex recognition of young form. In the material at the writer's disposal, a male measuring a length of 49.4 mm in body-length (12.9 mm carapace-length) is found provided with well defined external opening of vas deferens (Fig. 1, *A*) by aid of a magnifying-glass. Since the sex recognition of the young form of this lobster appears to be possible by this point at least on them larger than that given in this place. Also pleopods give an important trait for sex recognition of this animal. Exopodite of the third pleopod of female, 71.2 mm long, is observed a little larger in comparison to that of a male, 70.5 mm in body-length (23.2 mm in carapace-length) (Fig. 1, *H*). Accordingly the sex recognition basing on this matter seems to be considerably difficult. In this connection, it may be written herein that the spinous protuberance of propodus of the fifth leg, which makes in female an incomplete chela with the dactylus, shows no difference in size and feature in such male and female as 70.5 mm and 71.2 mm long respectively (Fig. 1, *E*, *F*). Therefore this trait is also not available for the purpose in question.

Distribution: Indopacific, known from Japan, Hawaiian Island, and Tahiti to New South Wales (Australia), and Natal (South Africa).

### *Panulirus longipes* (A. Milne-Edwards)

(New Japanese name: Kanoko-ise-ebi)
(Pl. III, Text-figs. 2–3)

*Palinurus longipes*, A. Milne-Edwards, 1868, p. 87, Pl. 21; Richters, 1880, p. 161.
*Palinurus* (*Panulirus*) *longipes*, Miers, 1880, pp. 379–380.
*Panulirus japonicus*, Gruvel, 1911, pp. 28–29 (part), Pl. 5 fig. 3; Holthuis, 1946, pp. 123–125 (part).
*Panulirus longipes*, Sheard, 1949, pp. 1–45.

A female is examined. It is taken from Kominato fish market, Chiba Prefecture, on August 19, 1952, by Mr. Tatsuyoshi Masuda of the Kominato Marine Biological Laboratory of the Tokyo University of Fisheries. The specimen, on which the present description is based, measured a length of 137 mm in body-length (46 mm in carapecial length).

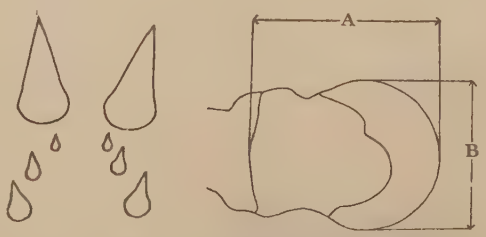


Fig. 2. Showing arrangement of spines and spinules of dorsal surface of antennal segment of *Panulirus longipes* (A. Milne-Edwards) (Left), ×3; and schematic showing of measurement method of eye (Right).

Antennal segment, from which antennae shoot out, has two principal spines and three pairs of spinules arranged in two raws of three immediately behind the principal spines. The spinules become larger in size posteriorly, and the width of the raws becomes wider backwards as seen in Fig. 2, Left.

Eye measures 6.5 mm (B) in length between anterior and posterior rims of cornea. Ocular segment is 7.0 mm (A) in length measured dorsally. Proportion of B/A is 0.93.

Life-colour of the specimen is as follows according to Mr. T. MASUDA, by whom the specimen is obtained. Body is of cobalt blue in ground colour. Tip of frontal spines and that of spines lying anterior to cervical groove is of an orange colour. Whilst tip of spines laid down posterior to cirvical groove is white. Abdomen is set forth with many whitish spots. A larger spot, ranged from 2 to 2.5 mm in longer disameter, is present near anterior base of pleuron of each abdominal segment. Other spots are smaller in size, about 1 mm in radius. Abdominal pleura are deep red coloured on anterior base and on posterior margin. Ventral surface of thorax is irregularly stained with orange and white colours. Eye stalks yellowed in upper surface. All pereiopods are also of a cobalt blue likewise in body, but are orange in coxa, basis, dactylus, and both proximal and distal ends of all other pedal segments. Regarding to telson and uropods, posterior edge of calcified portion is red, and soft parts are brown.

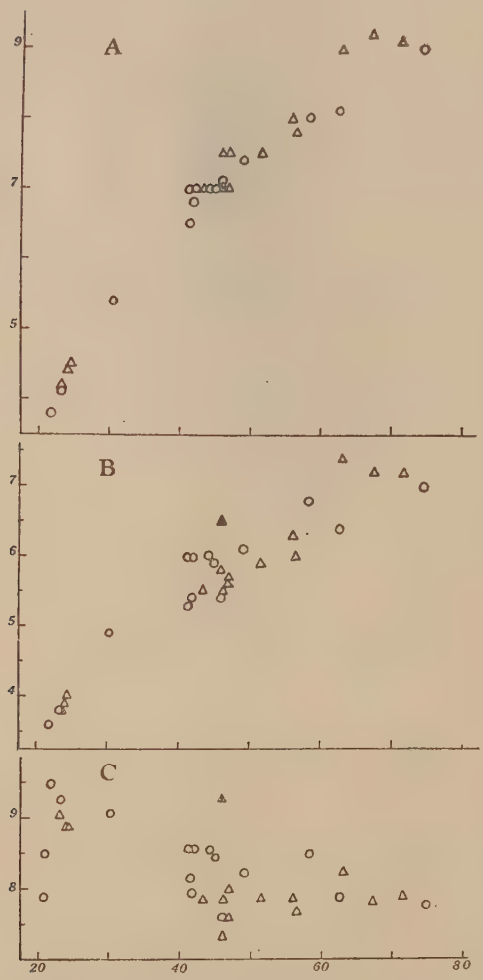


Fig. 3. Length of ocular segment (A), cornea-diameter (B) (See text), and B/A (C) in relation to carapace-length (Abscissa). Unit of length, mm. Circles, male; triangles, female. Soft marks, *Panulirus japonicus*; solid marks, *Panulirus longipes*.

The present specimen well agrees to the figure given by GRUVEL (op. cit.) and to the description made by MIERS (1880) in general respects. Only difference is that the thoracic legs

of the specimen at the author's disposal have no blotches which are present on the photograph given by Gruvel. But such discrepancy appears to the writer to be slight. Besides the present specimen is well in accordance to the description set forth by Sheard (1949) in the respect of possession of spinules arranged in two raws immediately behind the two main spines of antennal segment. So that the present author identifies the specimen at his disposal to the species, *P. longipes*.

Gruvel (op. cit.) has united the present species to *P. japonicus*. Also Holthuis (op. cit.) has of late conjoined it to *P. japonicus* because of that the difference found on the colouration only between the two forms may be referred to a local variation. The present author, however, is inclined to think that it is better to split *P. longipes* from *P. japonicus* by reason that the former has well defined morphological characteristics as given in the key besides different colouration.

Distribution: Indopacific. Records in literature are: New Hebrides, Coral Sea (Miers, 1880); Christmas Islands (Calman, 1909); Western Australia (Sheard, 1949); Mauritius (Richter, 1880; Miers, 1880; Monod and Petit, 1929); Zanzibar (A. Milne-Edwards, 1868).

### *Panulirus versicolor* (Latreille)

(Japanese name: Goshiki-ebi)

(Pl. V)

*Palinurus versicolor*, Latreille, 1804, p. 394.
*Palinurus fasciatus*, De Haan, 1841, p. 159, Pl. 43–44, fig. 2.
*Panulirus ornatus taeniatus*, Gruvel, 1911, p. 48, Pl. 6, fig. 3.
*Panulirus versicolor*, Dd Man, 1916, p. 55, Pl. 2, fig. 7; Maki and Tsuchiya, 1923, p. 83; Estampador, 1937, p. 497; Holthuis, 1946, pp. 142–145, Pl. 7, fig. j, Pl. 9, b, Pl. 11, fig. e, f, m (ubi synon); 1953, p. 50; Kubo, 1950, pp. 91–98, figs. 1–4 (for puerulus); Barnard, 1950, p. 553.

Three specimens were examined. Of which, one is a large adult male, 305.5 mm in body-length (106.0 mm in carapecial length), obtained from Hachijō Islands lying near 35°N, 140°E, in 1953 by Mr. Osamu Umebayashi (Pl. V). Other two ones are young. One of which measures a length of 60.4 mm in body-length (21 mm in carapace-length), taken from the waters about 2 m deep at Misaki, Kanagawa Prefecture by Mr. Nagao Asano. The other one, 47 mm long (16 mm in carapace-length) was fished by a lobster-net, a kind of gill-net, from Habu, Ōshima, ca. 100 km southwards of Tokyō, on September 7, 1953 by Mr. M. Igarashi.

As noted already in the section A, only an authentic record for the capture of adult of this species from the main Islands of Japan has been done by Maeda (1940, p. 45). His specimen, that is landed at Ōsaka fish market, is very large in size (actual size not recorded) according to his photograph, and sex unknown. The puerulus of this species occurs in costal waters of Izu Peninsula as given by Kubo (1950).

Distribution: Indopacific, ranging from Japan to Fiji, Australia, Natal,

and Persian Gulf. Misaki (ca. 35°9′N, 139°38′E) may be the northern limit of the geographical distribution of this species.

### *Panulirus penicillatus* (OLIVIER)

(Japanese name: Shima-ise-ebi)
(Pl. VI)

*Astacus penicillatus*, OLIVIER, 1791, p. 343.
*Senex penicillatus*, ORTMANN, 1891, p. 28.
*Panulirus penicillatus*, BATE, p. 82, Pl. 12, fig. 2; GRUVEL, 1911, p. 31, Text-fig. 13, Pl. 2, fig. 4; DE MAN, 1916, p. 45, Pl. 2, fig. 6; MAKI and TSUCHIYA, 1923, p. 81; HOLTHUIS, 1946, p. 125–128 (ubi Synon); 1953, p. 50; BARNARD, 1950, p. 550, fig. 102, e.

Examined a male, 146 mm in body-length (54.6 mm in carapecial length). It is taken from Habu, Ōshima (Izushichitō) on September 26, 1935 by Mr. M. IGARASHI. This makes the first record of this species from Japan.

Distribution: Indopacific, ranges from Japan (Ōshima, Izushichitō) to Hawaiian Islands, Galapagos Islands. Tahiti, Madagascar. Mozambique, and Red Sea. The Japanese locality given above is likely to be northern limit of the geographical distribution of this species.

### *Panulirus homarus* (LINNAEUS)

(Japanese name: Kebuka-ise-ebi)

*Cancer homarus*, LINNAEUS, 1760, p. 633.
*Palinurus burgeri*, DE HAAN, 1841, p. 159, Pls. 43–44, fig. 1.
*Panulirus burgeri*, DOFLEIN, 1906, p. 198; GRUVEL, 1911, p. 32, text-fig. 14, Pl. 1, fig. 6; BARNARD, 1950, pp. 548–549, fig. 102, c, d.
*Panulirus dasypus*, DE MAN, 1916, p. 48; 1924, p. 52.
*Panulirus homarus*, HOLTHUIS, 1946, pp. 128–134 (ubi synon).

From Japan, only several records of collection of this species are known according to HOLTHUIS (1946, p. 134). Those records were made by DE HAAN (1841), HERKLOTS (1861), DOFLEIN (1906), and others. DOFLEIN taken it from Sagami Bay, but detailed locality of other investigators are unknown. Since above records, this species has not been known from Japan.

Distribution: Indopacific, ranging from East Pacific Ocean (Marquesas Islands) to Red Sea and East coast of South Africa.

### *Panulirus dasypus* (H. MILNE-EDWARDS)

(Japanese name: Samehada-ise-ebi)

*Palinurus dasypus*, H. MILNE-EDWARDS, 1837, p. 300.
*Senex dasypus*, ORTMANN, 1891, p. 33.
*Panulirus dasypus*, DOFLEIN, 1900, p. 131; GRUVEL, 1911, p. 34, text-fig. 15, Pl. 2, fig. 5; BALSS, 1914, p. 77; PARISI, 1917, p, 8; MAKI and TSUCHIYA, 1923,

p. 86; Holthuis, 1946, pp. 134–136 (ubi synon); Barnard, 1950, p. 549.
non *Panulirus dasypus*, De Man, 1916, p. 48; 1924, p. 52.

This species has been known from Japan by Doflein (1900) and Pesta (1915). Pesta caught it from Yokohama (Holthuis, 1946, pp. 135–136). Doflein's locality is unknown. This animal seems to be rare in Japan because of this lobster has not been taken from Japan since the time of Doflein and Pesta.

Distribution: Indopacific, known from Japan and Formosa to New Guinea, Madagascar, Natal (South Africa) and Sokotora (Arabian Sea).

### *Panulirus polyphagus* (Herbst)

*Cancer (Astacus) polyphagus*, Herbst, 1793, p. 90, Pl. 32.
*Palinurus fasciatus*, Fabricius, 1798, p. 401; H. Milne-Edwards, 1837, p. 295.
*Panulirus fasciatus*, Gruvel, pp. 41–43, text-fig. 19, Pl. 5, fig. 2.
*Panulirus polyphagus*, Holthuis, 1946, pp. 136–138 (ubi synon).

In regard to this species, only a record of collection from Japan is done by Doflein (1900). Its detailed locality is unknown. This form also seems to be very rare in Japan, if it would be present, as this species has not been caught from Japanese waters since the record of Doflein.

Distribution: Indopacific, extending from East Pacific (Tahiti) to Great Barrier Reef, Natal (South Africa), and Baluchistan (Arabian Sea).

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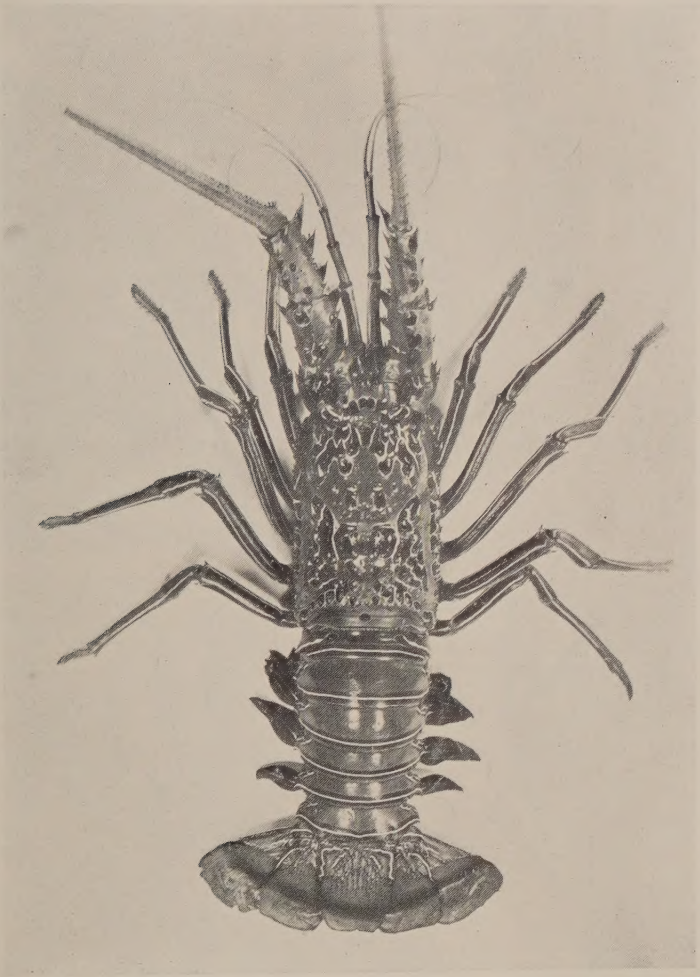
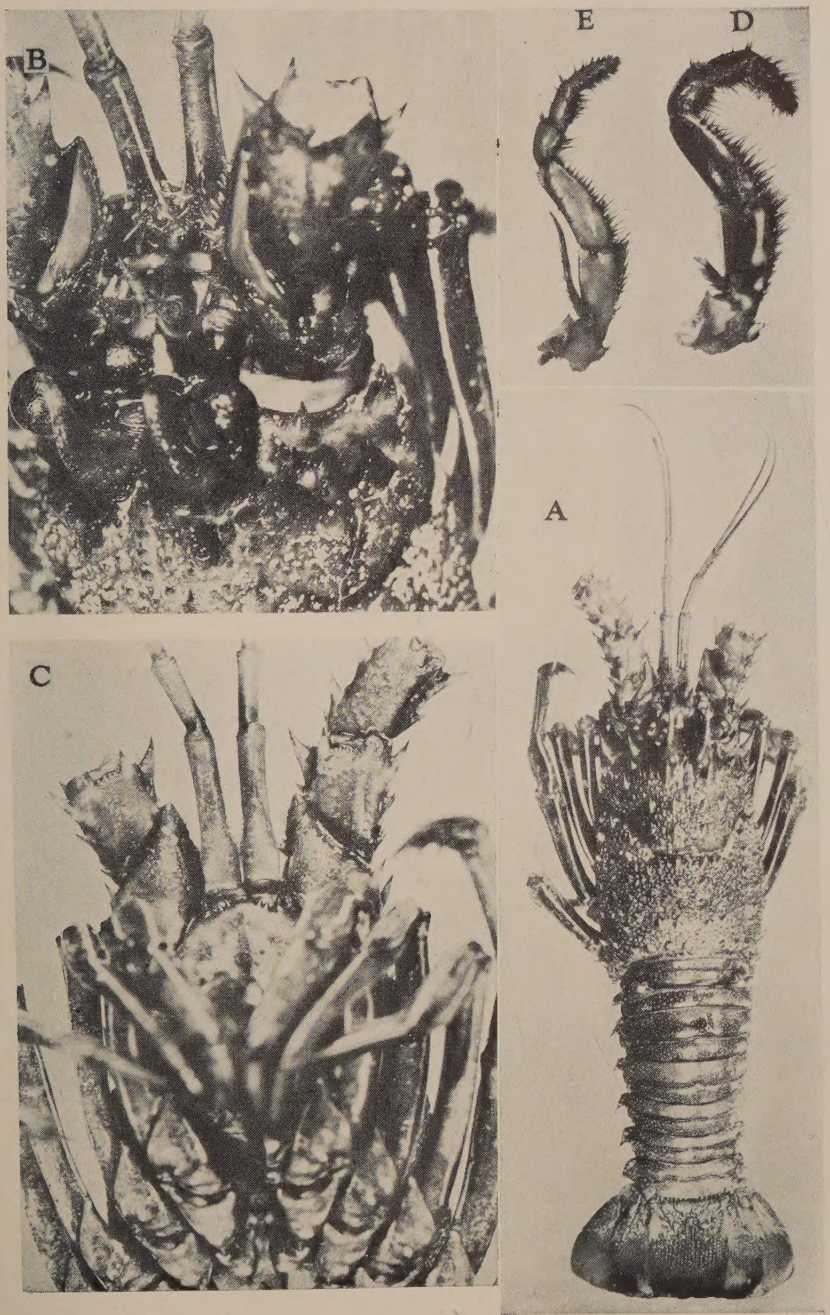
Pl. III. Dorsal aspect of a female of *Panulirus longipes* (A. MILNE-EDWARDS), 137 mm in body-length (46 mm in carapecial length).

Pl. IV. Ventral view of the same specimen given in Pl. III.



Pl. V. Dorsal aspect of a male of *Panulirus versicolor* (LATREILLE), 305.5 mm in body-length, 106.0 mm in carapace length, taken from Hachijō jima.

Pl. 6. *Panulirus penicillatus* (OLIVIER), male, 146 mm long, 54.6 mm in carapace length (A–D), and third maxilliped of *P. longipes* given in Pl. 3. A, dorsal aspect; B, dorsal aspect of frontal parts especially showing four spines of antennal segment; C, ventral view of frontal parts especially showing spinulation of epistome.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